ANNALS

of the

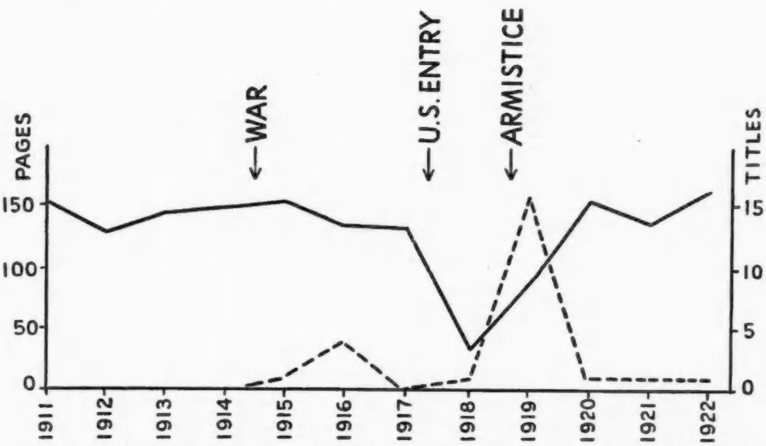
Association of American Geographers

Volume XXXI JUNE, 1941 No. 2

War, Peace, and Geography - - An Editorial Foreword

A RECORD OF PEACE AND WAR

The first twelve volumes of these ANNALS were published annually. Each carries the record of activities during the preceding year. The period covered was broken in the middle by the First World War. The appended table crudely but eloquently expresses the relation of the geographic profession to peace and war at that time.



Data derived from Volumes 1–12 of the ANNALS. The solid line represents total pages printed. The dash line represents the number of titles published on subjects inspired by the war.

For a year and a half after Europe was fighting, the number of pages published in the ANNALS grew, and for two subsequent years the shrinkage may be regarded as fluctuation, being no more pronounced than during one post-war year. With American entry into the conflict the ANNALS shrank to the dimensions of a single paper. The year which brought the armistice showed some increase, and another year of peace saw recovery to the pre-war level. These figures tell a story of scholarly, peacetime aloofness from a distant war; then total abandonment of wonted ways as the members of the Association were suddenly absorbed in duties connected with American participation in that war and in the peacemaking which followed it.

The disruption to peacetime geography caused by unforeseen demands upon a small professional group is confirmed by the record of services rendered to the nation by more than fifty members of the Association—nearly half the total membership. [Vol. 9 (1919), 49–70.] In addition, practically all the younger geographers, not yet members of the Association, were also devoting their full time to the war effort. A few of these were using their geography. Many more were serving in the army or navy, at jobs in which their professional training and qualifications were rarely, or only incidentally, utilized.

Quite as illuminating as the above numerical record, is the evidence of geographers' interest in problems presented by war, disclosed by papers presented during these years at meetings of the Association or published in the ANNALS (and shown on the graph).

After half a year of war in Europe, one member published an abstract dealing with strategic geography suggested by the war. [5 (1915), 142.] A year later four other members submitted papers related to the conflict. One of these treated the war in general, the others looked at particular aspects of it. [6 (1916), 124, 126, 128, 137.] Four months before the United States entered the war, a meeting of the Association heard not a single paper on a military subject.

The shift to wartime gear was sudden and complete. By the end of 1917 the members of the Association not engrossed by direct participation in the war effort were carrying heavy loads of work in order to maintain a semblance of peacetime geographic programs. No meeting was held in that year. The address of the president for 1917, which constitutes the entire 1918 volume of the ANNALS, had a theme inspired by the war.

When, at the end of two years, the Association reconvened six weeks after the Armistice, the war had become uppermost. Every page of abstracts of papers presented at that meeting carries one or more titles on the war. The total number of titles is sixteen, one over half of all. [9 (1919), 71–7, 83–8.] At this meeting geographers garnered the scientific

fruits of their active collaboration in the national emergency. The fact that the meeting was held in Baltimore, close to the national capital, doubtless permitted participation by many geographers at that time still engaged in Washington on tasks connected with the war or with the treaties of peace. Presumably the harvest would have been still greater if a number of the members had not been abroad, occupied with the peace treaties.

As the number of papers presented at the annual meetings and the pages devoted to publication regained or surpassed their pre-war level, expressions of interest in the geography of war dropped abruptly almost to zero. Each of the post-war ANNALS through volume 12 contains but a single pertinent title. These appear to have grown out of wartime activities, although two of the three concern the peace rather than the war itself. [10 (1920), 154; 11 (1921), 129; 12 (1922), 158.]

COMPARISONS WITH THE PRESENT CRISIS

Between 1919 and 1939 the number of professional geographers increased notably, although they are still few. More important, the major expansion occurred in aspects of the subject traditional in Europe, which had been little pursued in America prior to the First World War. For this broadening of base the war was to a considerable degree responsible. It awakened wide interest in the nature of the places where fighting occurred, it brought to public attention the importance of earth resources in the economic life of nations and in directing national policy, and many geographers had been given stimulating opportunities to view their subject afresh in the practical atmosphere of wartime jobs. The new orientation brought human geography to the side of physical geography, which had dominated the field before 1914. For a time economic aspects were paramount in both systematic and regional studies. Then came a trickling but increasing volume of publications in which political patterns were ranged alongside the economic, climatic, and edaphic, or singled out for special study. Except for the knotty problems presented by social geography, the American student as a result learned to view the earth in all the complexity of its natural and cultural features. He investigates and so far as possible measures the areal differentiation of earth conditions and earth resources with reference to humankind, whether they are considered as a platform for peace or a springboard for war. Techniques in physical geography already familiar twenty-five years ago, have been augmented by parallel but distinct techniques in human geography.

When Europe burst into war again in 1939, American geographers were ready to speak and move promptly and to the point.

Before the end of 1939 a plan was made for collecting and collating the

specialized information and skills possessed by geographers. This project was carried out through a committee of the National Research Council; subsequently it was enlarged and merged with the National Roster in recording the qualifications of all scientific men. The activity of geographers in the National Research Council during the interval between the two wars provided this and other means of focussing the geographic discipline upon national needs.

Needless to say, nearly all geographers possess cartographic training which can be put to immediate use by the government when needed. Numerous others are qualified in branches of physical geography to perform well established technical tasks. The rest possess special knowledge of specific regions all over the earth, or a world-wide comprehension of particular aspects of man in his varied habitat. It is this last kind of geography especially, which the Germans have known how to utilize more fully and effectively than has any other nation.

During the past decade our own government has been employing a rapidly increasing number of geographers in peacetime activities. It is now becoming aware of the geographers' potential contribution in the emergency created by the European war. A few reserve officers have been called into active duty to work on geographic problems, and a larger number of civilians is engaged at applied geography in the military establishment. The transition from ordinary pursuits of peace has been facilitated by the considerable group of geographers already working full-time or part-time on governmental programs. This strikingly contrasts with early stages of the similar emergency twenty-five years ago, when the sole geographers in federal service were members of the Geological Survey and the Weather Bureau.

The geographic profession itself also gives evidence of being far more conscious of its opportunity to serve the nation than on the earlier occasion, and of being prepared to function in a far wider variety of fields.

SOME CONTRIBUTIONS FROM GEOGRAPHERS

European nations, particularly Germany, have made fuller use of contributions which geographers can make to national affairs, than has been customary on this side of the Atlantic. As yet it is not clear exactly what demands for service our government will make upon our profession. If the war is prolonged, the levies on so small a group are bound to exceed the numerical capacity of its personnel, even if every research worker in the field is given full scope to use his technical training. The German example makes it vital that the government make provision to use this small, highly trained personnel in the field of its competence, at the same time interrupt-

ing as little as possible the continued training of recruits to the profession. To waste trained personnel is dangerous, as is being amply demonstrated by the crucial role applied knowledge of geography is playing daily on European battlefronts and in occupied territory, as well as by our own nation's experience during the First World War.

The record of the year and a half since the war began proves abundantly that geographers are eager and ready to serve. In contrast to a quarter century ago, the Association meeting following the declaration of war concerned itself deeply with the geographic implications of the struggle—in Europe, in the United States and in the world as a whole. Once again the ANNALS sheds light upon the attitudes and accomplishments of the geographic world. The issue which reviews that meeting contains thirteen abstracts dealing with world or national affairs. Eight of these make direct reference to the war. [30 (1940), 46–79, *passim.*] A year later (December, 1940) the Association joined with the Section for Geology and Geography of the American Association for the Advancement of Science, to present a day of papers on the subject "The Geography of National Defense."

The papers heard at that meeting suggested the desirability of presenting to a wider audience samples of some kinds of contributions which geographers are prepared to make during the period of wartime emergency, and later during the reconstruction that will be required in making and keeping the peace.

In preparing an issue of the ANNALS pursuant to this proposal, five of the papers offered to the meeting are included in revised form. The sixth might well have found a place on the same program, but stems from the 1939 Chicago meeting of the Association.

Participants in the current issue of the ANNALS have construed broadly the announced subject: "The Geography of National Defense." The papers range from considerations of military and naval defense of specific areas to studies of geographic conditions critical in war and peace and devices for measuring such matters and portraying them on maps.

Obviously no six papers can do more than suggest a *few* of the multifarious endeavors of geographers which bear on a crisis such as the present. Rather they should be taken as examples of a mode of thought and of special categories of information rarely represented among students of world or national affairs, outside the geographic profession.

The first three articles make up a coherent group dealing with national defense of critical areas. They are followed by three unrelated studies. One of these treats of petroleum as a factor in cataclysmic changes in contemporary modes of life, war being a symptom of painful readjustments

brought about by newly utilized natural resources. Another considers the extension of map techniques as a means to further world harmony. The third analyzes the varied consequences to the land which follow upon the occupance of the earth by humankind, consequences which are likely to be accelerated by the heavy draft of war demands.

Geography and the Defense of the Caribbean and the Panama Canal*

G. S. BRYAN

Captain, U. S. N.

The story of the West Indies and the Spanish Main is one that for many years has appealed to the imagination of those who love adventure.

The treasures of the Indies, which made Spain the greatest nation in Europe, also served to arouse the jealousy and cupidity of the rest of the world. Pirates and buccaneers early began to ply their trade against the treasure galleons that cruised in those waters. Such men as Morgan, Drake, and Hawkins, with the more or less tacit approval of their sovereigns, went even further by raiding and sacking the various settlements founded in that region by other nations. The destinies of Europe later began to be settled by naval battles fought in this area, and such names as Nelson, Hood, Rodney, and DeGrasse appear in the records.

Napoleon entered the contest with his ill fated expedition in Hispaniola. When he decided to invade England, he planned to unite the fleets of France and Spain in the harbor of Martinique, from which point, the combined fleets were to sail against England.

At the end of all this warfare, practically all of the West Indies remained in the possession of the various European powers, while most of the mainland countries of North and South America succeeded in gaining their independence. The insular nature of these possessions was a geographical feature which prevented them from having a fate similar to that of their continental neighbors. Up to the present time, only Spain and Portugal have been driven from this hemisphere.

Let us look at the map of this area (Fig. 1). The Caribbean is separated from the Gulf of Mexico and the Atlantic Ocean by a string of islands stretching roughly in an arc of a circle from the Yucatan Peninsula to the northern coast of Venezuela. These islands are mostly mountainous, are separated generally from each other by deep channels, and possess a large number of fine harbors.

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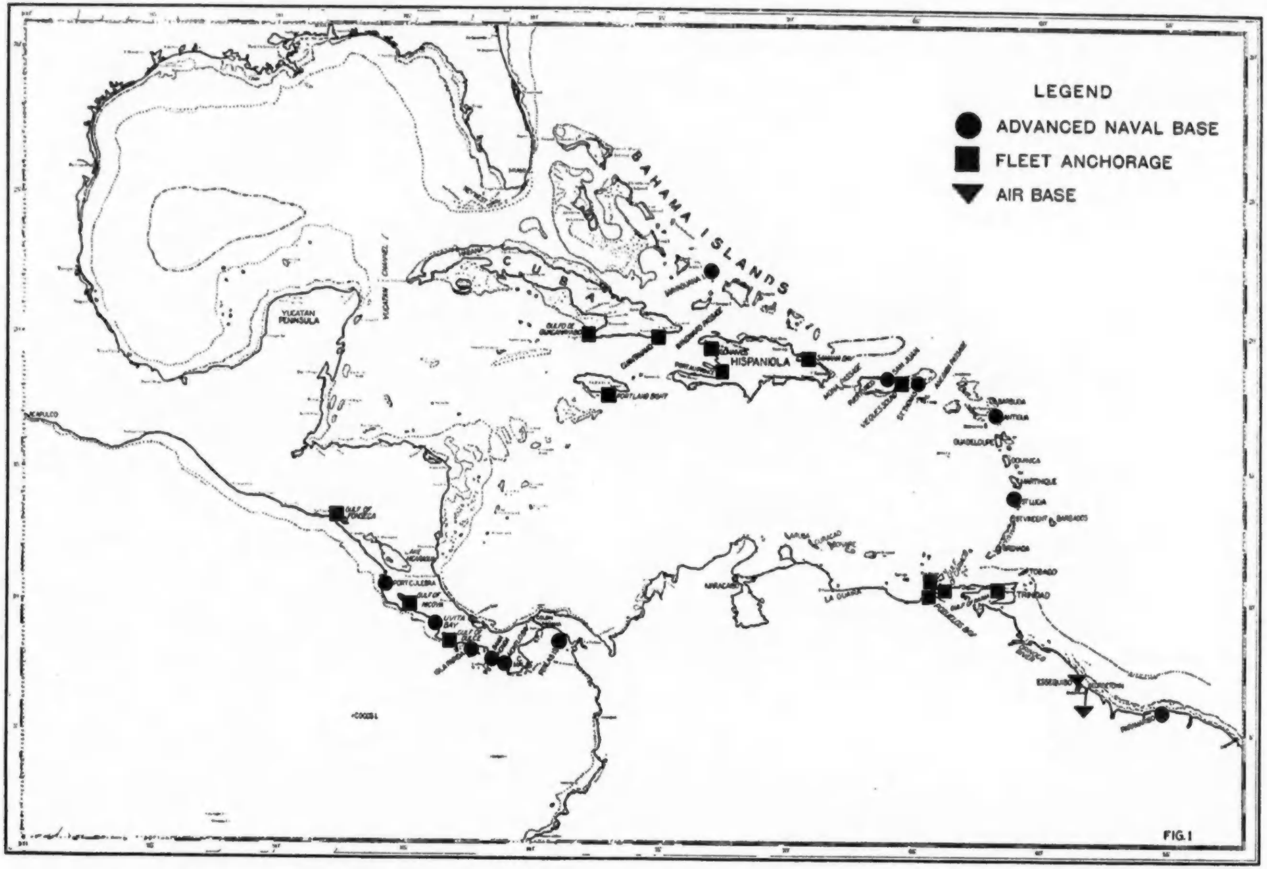
* *Author's Note:* Any opinions expressed in this paper or any mention of plans refer only to those of the author himself and should not be construed as representing in any way those of the Navy Department or its responsible officials.


LEGEND
ADVANCED NAVAL BASE
FLEET ANCHORAGE
AIR BASE
BAHAMA ISLANDS
CUBA
HISPANIOLA
YUCATAN PENINSULA
YUCATAN CHANNEL
PORTLAND BIGHT
GULF OF FONSECA
PORT CULEBRA
LIMON BAY
LA GUAIRA
MARACAIBO
TRINIDAD
TOBAGO
GRENADA
BARBADOS
ST. LUCIA
MARTINIQUE
DOMINICA
GUADELOUPE
ANTIGUA
BARBUDA
SAN JUAN
ESSEQUIBO
ACAPULCO
FIG. 1

The climate of this region is, of course, tropical. There is a rainy and a dry season; the former usually lasting from April to December and the latter the remainder of the year. The Caribbean is in the general belt of the North-East trade winds. This was a point of considerable importance in the days of sailing ships when the direction and force of the wind had a vital effect on the strategy and tactics of that day. At the present time, we need only note in this connection that with the prevailing wind from the northward and eastward, such anchorages as can be found on the western side of the islands are usually protected from the weather.

From a physical standpoint, the northern section of the West Indies consists of the comparatively large islands of Cuba, Jamaica, Hispaniola, and Puerto Rico. The eastern section comprises a chain of smaller islands leading from eastern Puerto Rico to Venezuela.

There are only three entrances from the northward; one through the Yucatan Channel to the westward of Cuba; one through the Windward Passage between Cuba and Hispaniola; and one through Mona Passage between the latter and Puerto Rico. Anegada Passage forms the north-eastern channel and from this point to the southward, passages exist between all the larger islands. Traffic to and from the Panama Canal must of necessity pass through the Caribbean and from a strategic point of view, these islands may be considered as outposts guarding it.

POSSIBLE LINES OF ATTACK

Before we can proceed with a logical discussion of any plans for the defense of this area, we must arrive at some conclusions regarding the most probable line of attack that may be expected. What nations can be visualized as possible invaders of this section of the world; what will be their object in making the attack; what form will the campaign of invasion take, and from what direction will they strike?

International political conditions often change quite rapidly and each change in this respect may necessitate a similar change in our plans. At the present time, however, it is clear to everyone that the most probable future threat of an attack is represented by a combination of European and Asiatic powers.

The basic objective of such an attack, if it comes, will undoubtedly be one of simple conquest with a view to the annexation of the territory as a colony. A secondary objective might be the destruction of the Panama Canal.

The canal is located approximately from one thousand to twelve hundred miles from the chain of islands which comprise the West Indies. Control of this important waterway would be a rare prize for any foreign power.

For the United States, however, it is a vital necessity as an adjunct to the national defense. As long as our interests are threatened in both the Atlantic and Pacific Oceans, we must maintain in each of these oceans a sufficient part of our naval forces to cover the particular situation at hand.

There still exists a possibility that this hemisphere may have to face an attack by the combined navies of all Europe and Asia. Our projected two ocean navy is not yet in existence. Until it is available, it is vital that we be able to shift the units of our Fleet back and forth through the Canal to meet any change in the international political situation.

Any closing of the Canal might result in leaving our forces in either ocean in a position of inferiority at a time when an invasion was threatened from that direction. The importance of the Canal to our national defense would encourage an enemy to make an effort to destroy it or at least to render it inoperative.

This objective might be accomplished, either by an actual seizure of the Canal or by a bombing raid. With the chain of islands of the West Indies a thousand miles distant acting as outposts, a raid from the Atlantic would be difficult. In the Pacific, however, a sudden raid by a swift striking force with aircraft carriers launching bombing planes against the locks from some distance away, might give sufficient promise of success to encourage an enemy to attempt it. If it were successful, the disabling of the Canal might alter the strategical situation enough to decide the outcome of the war.

In the Atlantic Ocean, a glance at Figure 2 will show the immense distances that must be traversed by an expeditionary force seeking to invade this area. From the Azores to the nearest port of the West Indies is about 2,500 miles; from the Cape Verde Islands about 2,200 miles; and from Dakar about 2,700 miles.

The convoying of a large expeditionary force a long distance overseas is a difficult and dangerous undertaking unless the enemy fleet has first been defeated, and command of the seas is obtained. The invading force in such a case is greatly handicapped by having a large convoy to defend against constant attacks from surface ships, submarines, and planes, and consequently is unable to maneuver freely at the time when action is imminent. Many of his ships might be short of fuel. If defeated, or even in the case of an indecisive battle, there are no bases available to which his damaged ships can retire for fueling and repairs. His air force is limited to those planes which can be transported on aircraft carriers.

The defending fleet, on the other hand, has the advantage of being free to maneuver and of having the initiative—of being able to select its own time and position for the attack. Its ships can be kept freshly fueled and if any are damaged in action they will have near-by bases to fall back on.

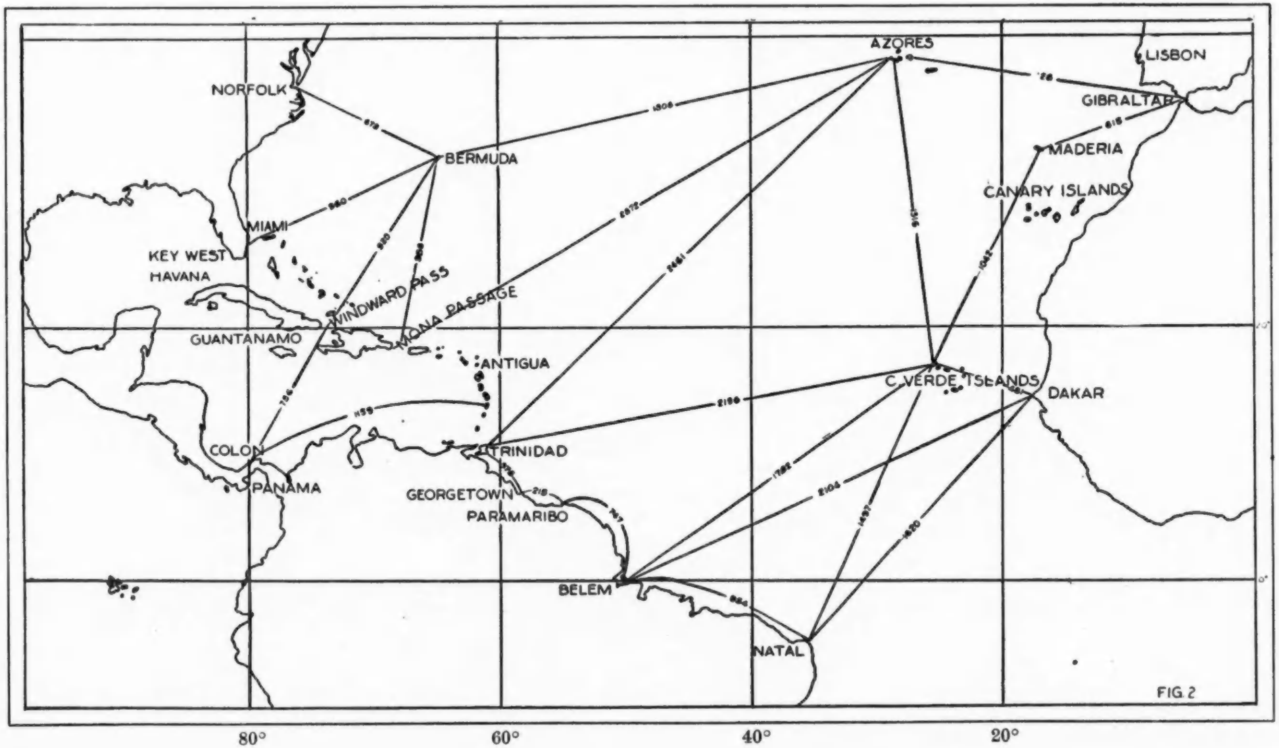
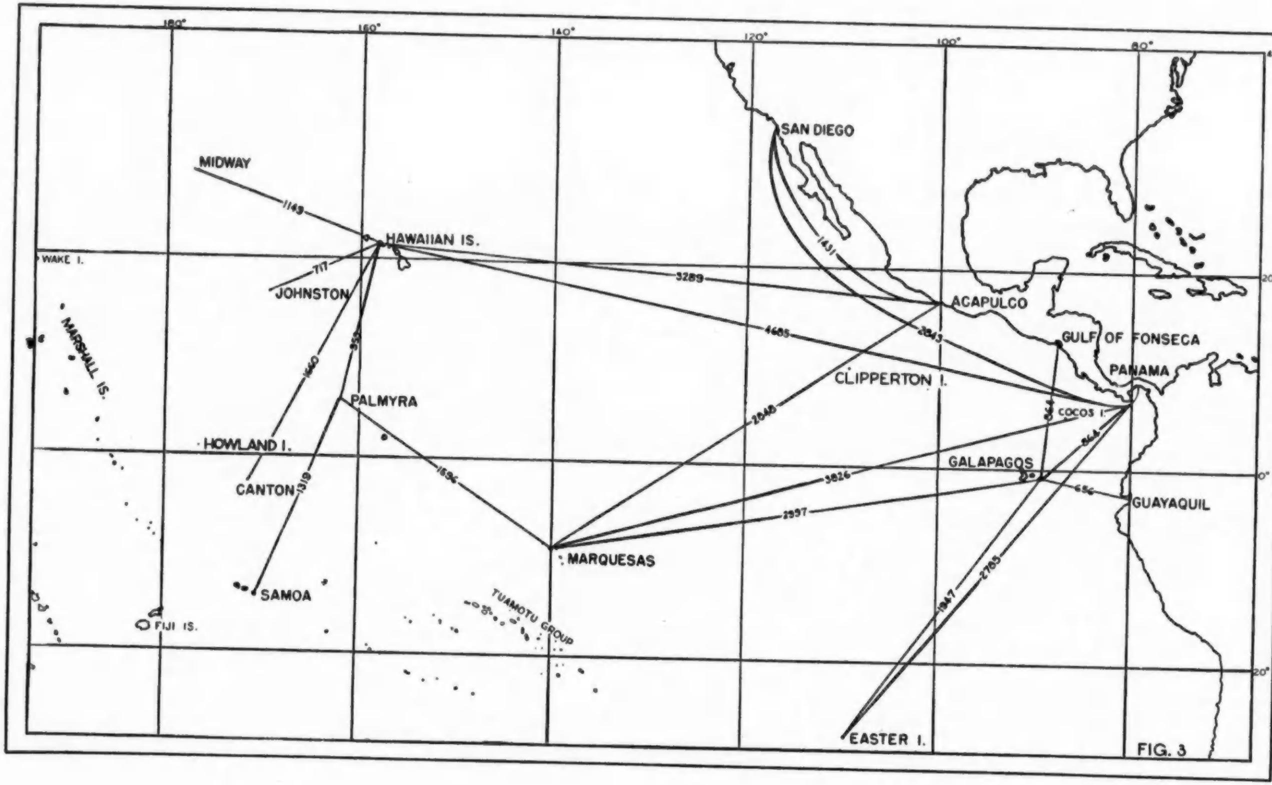

NORFOLK
BERMUDA
AZORES
LISBON
GIBRALTAR
MADERIA
CANARY ISLANDS
MIAMI
KEY WEST
HAVANA
WINDWARD PASS
MONA PASSAGE
GUANTANAMO
ANTIGUA
C. VERDE ISLANDS
DAKAR
COLON
PANAMA
TRINIDAD
GEORGETOWN
PARAMARIBO
BELEM
NATAL
80°
60°
40°
20°

FIG. 2



180°
160°
140°
120°
100°
80°
40°
20°
0°
20°
MIDWAY
1149
HAWAIIAN IS.
WAKE I.
717
JOHNSTON
1660
MARSHALL IS.
PALMYRA
HOWLAND I.
CANTON
1319
1596
SAMOA
FIJI IS.
TUAMOTU GROUP
MARQUESAS
SAN DIEGO
1431
3289
4685
ACAPULCO
2843
2848
CLIPPERTON I.
GULF OF FONSECA
PANAMA
COCOS I.
GALAPAGOS
3826
2997
GUAYAQUIL
1947
2785
EASTER I.

FIG. 3

Shore based aircraft can aid them. It has the advantage of better knowledge of enemy movements and can accordingly plan attacks by destroyers and submarines.

The disadvantages and risks would be too great to justify an attack of this sort direct from Europe, with the United States Fleet still in existence. The same type of reasoning would prevent an enemy from proceeding via Bermuda and attacking from the northward. In this case for almost a thousand miles, the expedition would be subject to flank attacks from bases along the coast as well as from those in the West Indies.

The more probable line of advance for an invasion of the Caribbean Area would be via the west coast of Africa, thence to South America, where the convoy could be temporarily left behind at some base while the invading fleet first sought a decisive battle with the defending fleet. This would entail a much longer total distance but has many advantages.

An invasion by way of South America would permit an enemy to transport land planes to that continent and to use them to good advantage as he advanced northward towards the Caribbean. Any damaged ships might be able to retire on the temporary bases in his rear for refitting and repairs.

This route appears to have many advantages, from the enemy standpoint, over the direct approach from Europe, and we may figure this as his most probable line of attack, although the other still remains a possibility.

In the Pacific Ocean (Fig. 3), the distances to be traversed by an invading force are far greater than in the Atlantic. For instance, Panama is about eight thousand miles from Yokohama—about one third the circumference of the globe. The direct air line route—the great circle route—between these points, would pass through the Aleutian Islands and down the Pacific coast of the United States and Mexico. The most direct practical route for a fleet would be that via Honolulu. Other possible routes lead via the Carolines, Marshalls and some of the other island groups to the southward.

The Great Circle Route is impracticable because the only stops available are those along the Pacific Coast. The Hawaiian Islands could not be used as a stopping point until the United States Fleet had been disposed of, and any route to the southward would also be extremely risky as well as difficult as long as there was a strong naval force in Pearl Harbor and scouting forces in the various United States Islands to the southward—Wake, Johnston, Howland, Baker, Palmyra, Canton, Tutuila and others.

Unless the United States Fleet has first been reduced to a point of great inferiority, we can consider that a large overseas expedition against the Canal would be impracticable. As a matter of fact, there is very little reason for assuming that any Asiatic power would attempt to seize the Canal. If conquest were the motive, Panama and the Canal Zone would

not represent as rich a prize as the nearer and more desirable territory of Mexico and Central America, or of Colombia and Ecuador to the southward. The most attractive prize in Panama is the Canal itself and the control of traffic through it, and this would hardly be of sufficient value to an Asiatic nation to justify the effort involved in seizing it.

As explained previously, the Canal is of vital interest to this country inasmuch as without it we cannot shift the units of our Fleet from one ocean to the other to meet any threat that may arise. While the actual invasion of Panama may be considered impracticable, we might expect an enemy in the Pacific to attempt the destruction of the locks or other vital parts of the canal by a sudden raid. In fact, this constitutes the most probable objective of a hostile force which we need guard against.

To carry out such a raid, both secrecy and speed would be necessary. A raiding force for this purpose might include capital ships with their heavy guns for long range bombardment, aircraft carriers with their bombing planes, and transports with troops and equipment for a landing force to make a drive directly on the locks. Of course, high speed tankers would have to accompany them, at least for most of the distance, and occasional stops would have to be made for refueling. As such a force would plan on returning to its home ports after carrying out the raid, it would have to arrive on the scene with sufficient fuel to enable it to reach the first fueling port on the return cruise.

The requirement of secrecy would necessitate their following a general route well to the southward of Honolulu. Only in this way can they hope to avoid detection and at the same time have sheltered anchorages where they can refuel. If we look at Figure 3 we can see that, with the exception of the Galapagos Islands, the island groups nearest Panama are the Marquesas, some 3,800 miles away and Easter Island some 2,785 miles distant. These distances are so great that a final stop for fueling would most likely have to be made in the Galapagos Islands or on the west coasts of Colombia or Central America. From these points, the raiders would probably dash in at high speed and launch their attack.

In discussing the defense of this area, I am assuming that the attack would be resisted jointly by practically all of the nations of the Western Hemisphere. As the military and naval resources of this country are comparatively much greater than are those of other nations of the two Americas, this country would naturally have to bear the greater part of the burden of defense.

BASES FOR DEFENSE

Recent agreements with the Government of Great Britain have resulted

in making available to this country a number of harbors where we plan to establish bases for the operation of our naval and air forces. In addition, agreements have also been made, in some cases, covering the use by this nation's forces, of bases in other Pan American countries when those nations are united with us in a common defense against an aggressor. For the purpose of this paper I am assuming that all the harbors mentioned will be made available for the common use of our Fleet and planes and those of other American nations.

In preparing a plan for defense against the type of attacks which we consider most probable, we would follow the generally standard pattern of first stationing our forces at strategic points; second, scouting to obtain information of the strength, disposition, and probable intentions of the hostile forces; and third, concentrating our forces and attacking under conditions most favorable to ourselves.

Our scouting forces both surface and air, must be so disposed that they can carry out a scouting patrol covering all possible lines of advance of the enemy. Bases for their operation should be as far advanced as possible towards the direction from which invasion is expected.

Our light forces—light cruisers and destroyers—would require a protected anchorage where they could refuel between scouting operations. Such an anchorage could also be used by seaplane patrol squadrons and their tenders. While some permanent facilities, particularly for seaplanes, would be quite useful, they are not absolutely essential. These bases would be used not only by the light forces engaged in scouting but also by destroyers and submarines which might be assigned to attack the enemy in advance of his contact with our main body.

For land based planes a landing field would be required with the usual facilities necessary for their operation. This means a more or less permanent establishment with hangars, barracks, and storage for fuel.

Our main forces would be so located that they could concentrate between the enemy and his objective as soon as the necessary information of his approach was received. For the heavy ships, which represent the main body of the Fleet, large spacious deep water harbors are required. If possible, these should be more or less land locked for protection against submarine attacks and should be located in the rear of our advance bases. The general requirements are that they should be far enough to the rear for safety and far enough advanced to permit interception of the enemy at the desired point. Shore facilities for fuel, repairs and supplies are desirable at these bases also but are not essential.

We have then three classes of bases, each of which is needed for its specific purpose although the requirements of all three might be combined in one location. First, advanced naval bases suitable for light forces and sea-

planes—not very large in extent, of moderate depth and protected from wind and weather. Second, large protected deep water harbors which can accommodate a number of big ships and which preferably are capable of being protected against torpedo attacks. Third, military landing fields with the requisite facilities for the operation of all types of land planes.

Let us see how the distribution of harbors in the Caribbean fits in with our plans of selecting bases (Fig. 1) of the above types. For the advanced naval bases protecting the Caribbean, we start with Bermuda (not shown in Fig. 1) which is located as an outpost well to the northward and eastward. Any advance via the Florida Straits could be handled from the mainland. In the Bahamas this country has selected Mariguana Island, which guards the northern entrance to the Windward Passage, for a base in this region. Our base at San Juan can guard Mona Passage and Anegada Passage, and St. Thomas is also effectively located for use in this section.

The British island of Antigua controls the northern flank of the Lesser Antilles and we have an agreement covering the use of Parham Sound here as a base. The islands of Guadaloupe and Martinique belong to France. Martinique would afford a good base if it were available, but under present conditions it cannot be fitted into our plans. By agreement with the British, however, St. Lucia is available to us and this only leaves a gap of about 200 miles between that island and Antigua. At about the same distance to the southward, Trinidad and the Gulf of Paria close the gap to the mainland and complete our line of outposts covering the Caribbean.

All of the above harbors can be used as seaplane bases and in addition, this country, under agreement with the British, is establishing a seaplane base on the Essequibo River in British Guiana. Landing fields for the use of land planes also may be established at practically all of these bases.

With the exception of Trinidad, none of these harbors are suitable for anchoring our heavy ships. Also one of the requirements for our fleet anchorage is that it have a location somewhat to the rear of the line of outposts. Guantanamo Bay on the southeast coast of Cuba has long been used as our major naval base in that region. This bay is extensive enough to accommodate the major part of our Fleet.

Other large deep water anchorages in this area are Guacanayabo Bay to the westward of Guantanamo, Portland Bight in Jamaica, the Gulf of Gonaives, and Port au Prince, Haiti. Some of these are subject to the objection that they are comparatively open roadsteads and difficult to protect against torpedo attacks. Samana Bay at the northeast corner of San Domingo would make an excellent anchorage for a fleet with good protection. An anchorage can also be found to the eastward of Puerto Rico in Vieques Sound but this is also unprotected.

From this point we have to skip to Trinidad as there are no harbors capable of accommodating a large fleet in the Lesser Antilles. The Gulf of Paria to the westward of Trinidad is a fairly well enclosed body of water which is capable of anchoring the fleets of the entire world without difficulty.

A little over a hundred miles to the westward, there may be found plenty of anchorage space for our Fleet. Pozuelos Bay is a fine anchorage and in general all the space in the lee of Margarita Island can be used if an open roadstead is not too much of a handicap. In the Gulf of Cariaco can be found anchorages which could be well protected against torpedo attacks.

From our line of advanced island bases a patrol could be maintained by our light surface vessels and planes sufficiently far out to sea to detect an invading force well in advance of his arrival in this area. With the invading force once located, a continuous stream of information should be obtained concerning his movements. From the advanced bases, destroyers, submarines and bombing planes could direct attacks on the enemy by day and night as he advanced. Meanwhile, the various units of the fleet would be concentrating and proceeding to a position to intercept the enemy and give battle.

In the Pacific (Fig. 3), the situation is somewhat more difficult. We do not have such a string of islands available as outposts as we have in the Atlantic, and the speed of approach of the raiding force will be much greater. These disadvantages to us are offset somewhat by the lack of bases available for the raiding force for refueling. Also Panama is located at the head of the Bay of Panama which is roughly about a hundred miles square, thus giving us outposts approximately that distance from the Canal.

The principle of the defense is the same here as in the Atlantic. The raiding force must be located and our own forces must be concentrated to intercept and destroy it before the raid can be made effective. We must similarly make use of such harbors as are best suited for our purposes and of such areas as are available for our planes.

There is a deep water anchorage off Panama (Fig. 1) that could hold the Fleet but this is more or less of an open roadstead. As we round Cape Mala and follow up the coast of Central America we find also anchorages capable of accommodating the Fleet in the Gulf of Dulce, the Gulf of Nicoya, and the Gulf of Fonseca. The more northerly of these are perhaps better suited to guard against an attack on Central America than one directly against the Canal. There are no good fleet anchorages along the western coast of Colombia or Ecuador.

There are plenty of protected anchorages that are available to the northward that could be used for seaplane bases or for light forces and submarines. A number of such anchorages can be found in the Perlas Islands.

As we round Cape Mala and proceed up the coast, we discover Montijo Bay, Bahia Honda, Parida Island, Uvita Bay, and Port Culebra in addition to the above three gulfs that were mentioned as fleet anchorages; all of which are suitable for these operations.

The Pacific coast of Colombia is not well surveyed and, as far as we know, is also lacking in good harbors but possible anchorages for seaplanes and small forces of cruisers or destroyers can be found at a number of points along this coast.

The Galapagos Islands (Fig. 3), about a thousand miles from Panama, are located in an excellent strategic position as an outpost for the defending scouting forces. As can be seen from Figure 3, these islands are situated across the line of advance from the South Sea Islands and owing to the great distances involved, it would be practically impossible for a potential attacking force to transit these distances and return without a stop for refueling. For this purpose, only the Galapagos Islands, the coast of Central America and Mexico, and that of South America are available and detection of the hostile force should be certain if patrols are maintained at these points.

Obviously, the Galapagos Islands would be of considerable importance as a focal point for stationing an advanced scouting force of ships and planes. With a hostile force located from this point, the defending forces should have no difficulty in repelling the raid.

The influence of geographical features upon naval operations in an offensive or defensive campaign can, I hope, be visualized from a study of this paper. In any operation, every effort should, of course, be made to take advantage of such natural features as are available. In the final analysis, it is the strongest force at the decisive point that decides the issue. The development and use of the proper bases, however, should enable us to so dispose our forces that we can at least have a tremendous advantage at the decisive point.

Washington, D. C.
January, 1941.

The Defense of Greenland

WM. H. HOBBS

The occupation and subjection of Denmark by Nazi Germany, which occurred at the outbreak of the World War II, have brought the former Danish colonies that are within this hemisphere under the terms of the Act of Havana. The ratification of that pact by two-thirds of the twenty-one American Republics participating, has now made it fully operative.*

If occupied by an enemy, whether actual or potential, Greenland would constitute a menace to the security of both the United States and Canada, now joined in a national defense compact. Southern Greenland is distant only 1200[1] miles from the nearest frontier (northern Maine) of our national domain, and only 500 miles separate it from inhabited Canada (Labrador). From our new naval and air bases in Newfoundland, Greenland is barely nine hundred miles distant, thus well within the radius of action of modern bombing and pursuit planes.

Since Greenland is not self-supporting, our government soon after the outbreak of the War took steps to relieve the food situation, recognized a temporary state of quasi-independence, set up an American consulate at Godthaab in South Greenland, and stationed there a squadron of four armed revenue cutters. Canada also established a consulate in Greenland with the consul in charge long a resident of that island. The valuable aluminium ore (cryolite) which has long been mined at Ivigtut on the Arsukfjord in South Greenland, of which the major portion had before been shipped to Europe, has now been deflected to this country.

PHYSICAL CHARACTER OF GREENLAND

Looked upon as a military outpost of this country, Greenland offers difficulties as well as great advantages, due especially to its nearly unique physical character. In the possession of an enemy power it would offer a very serious menace to our security, while if in our own hands, through greatly extending our military bases toward Europe, our position would be greatly strengthened. Greenland stretches northward through twenty-three degrees of latitude, or about 1800 miles, and it has an extreme width of 800 miles (Fig. 1).

* Under this act American bases are now (May, 1941) being set up in Greenland.

[1] All miles are here English statute miles.

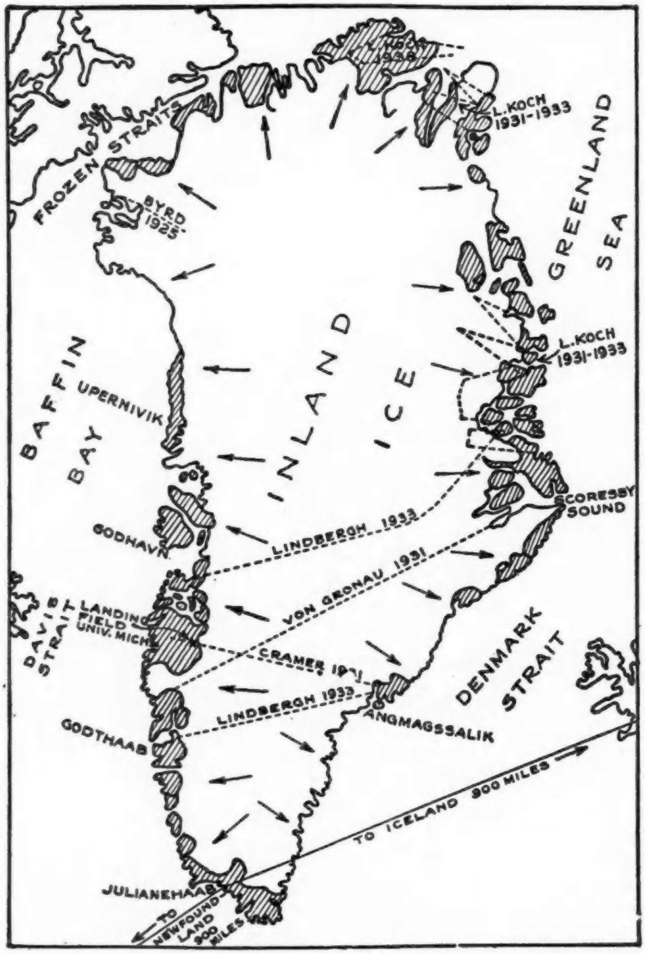


FIG. 1. Map of Greenland. Marginal land is shaded. Arrows show directions of strong surface winds. Dash lines indicate the flights of explorers. The special map of figure 3 surrounds the strategic position of Julianehaab.

Along the northern and northeastern coasts of Greenland the sea is frozen throughout the year and quite unnavigable, and for all save about one month, in August or September, its entire eastern coast is flanked by the impenetrable pack ice. During these few weeks only, its two great eastern

fjords, on which are located the Eskimo colonies and a few Europeans, can be reached by surface ships.[2] Under favorable conditions and with somewhat greater difficulty, inhabited fjords still farther to the north have been accessible for a very brief period. With use of an ice breaker of the Russian type, the two Eskimo colonies on the east coast might perhaps be made accessible from the sea for a somewhat longer period. The wide offshore belt of pack ice is explained by the drift of the sea ice from the Arctic Ocean along the Greenland east coast. Within this area the prevailing storm winds blow from the southeast and crowd the ice against the coast. This is especially the case to the south of the latitude of Iceland, where is the track of storms through the great atmospheric depression trough known as the "Icelandic low."

To the westward of Cape Farewell, the extreme southern tip of Greenland, these southeast winds blow parallel to the stretch of coast, and the pack is therefore open so that Julianehaab and Ivigtut are accessible by surface ships throughout the year, with the exception of about three per cent of the time when southwest winds prevail. The pack in this region, the *Storis* or "big ice," first makes its appearance off Julianehaab on an average about January 25th, though this varies greatly and it has been known to arrive as early as November 23rd and as late as March 25th. After passing Julianehaab and Ivigtut, the pack becomes open and drifts up the southwest coast of Greenland. Ships in approaching South Greenland keep west of Cape Desolation until near shore, after which Julianehaab is reached through more open water near the coast.

The greatest expanse of the pack is in the months of May and June, when it may reach as far as Godthaab, the capital of South Greenland. Within this pack there are nearly always open "leads" of water through which ships can maneuver, and open water often separates the pack from the coast. The pack south of Greenland begins to diminish in its expanse during the month of June, and is usually gone in August, though sometimes it lasts until October.

The Greenland west coast south of latitude 73° N. is usually accessible to surface ships during a summer season of five to six months—May to October. Within this stretch of coastland there is found a coastal ribbon of barren land which ranges in width from a few miles to more than one hundred. This ribbon is occupied by rugged mountains and plateau areas which extend up to 5000 feet and over in altitude, the whole intersected by

[2] This period varies from year to year, and there have been years when the one summer steamer of the Greenland government has failed to reach the settlements of Angmagssalik and Scoresby Sound.

a great number of deep fjords, many of them navigable by ocean-going vessels well up toward their heads.

With the exception of this bordering strip of land and a considerable area in the extreme northeast (Peary Land), Greenland is largely buried under a glacier of continental type which has the form of a flat shield or dome of snow-covered ice, which within the central area rises to about two miles above the level of the sea.

Within most of this vast interior region the surface of the snow-covered ice is so flat that its slight inclination is not detected by the unaided eye. Its surface, modeled by the fierce storms which sweep over it, has minor irregularities, drifts or *sastrugi,* which rise a few feet only above the general level. Speaking by and large, these minor irregularities of the ice cap surface are not of such size as to interfere seriously with the landing or taking off of airplanes. Such actual operation by planes has not been demonstrated in Greenland, but has on similar surfaces of the Antarctic continent.[3]

The actual central zone of the Greenland ice cap, which lies within that whose surface has just been described, and is perhaps a quarter of the entire ice cap surface, is similarly flat but is covered to a depth up to a foot or more by dry, mealy snow of dust-like fineness. This zone is separated sharply from the one which immediately surrounds it, and while that zone is swept by fierce storms blowing everywhere outward from the central axis of the ice cap, this interior one is characterized by relatively calm atmospheric conditions, and by contrast is intensely cold—the air temperature is often as low as 30° F. in midsummer. The daily range in temperature between midday and midnight is also double that within the zone surrounding, and one passes by sledge from one zone to the other within a few hours.

Surrounding both interior zones is a marginal zone varying in width from 30 to 50 miles, which becomes increasingly steep toward its margin. The ice within this zone is intersected by crevasses which descend far into the ice mass. Here the surface is in general wholly unsuited to the landing of airplanes, though behind the mountains which, like a great dam, wall in the inland ice, there are sometimes smoother belts on which landings could be made from planes. However, unless a depot of supplies were to be

[3] I have long felt that this operation of planes on the surface of the world's great areas of inland ice was entirely feasible, and when called in to advise Colonel Lindbergh before his Greenland flight under the auspices of Pan-American Airways, pointed out to him that the question should be settled before commercial flights over the ice cap were undertaken. He did not act upon the suggestion, and it remained for Lincoln Ellsworth to prove its feasibility through his landing and taking off from the quite similar ice surface of the Antarctic continent. Four times during his flight across the James W. Ellsworth Ice Plateau, Ellsworth made landings and take-offs. On one of these he withstood a forty-five mile blizzard for a period of seven days with his plane anchored in the snow surface.

prepared in advance, and this might be accomplished by the use of airships, dog sleds or tractors, there could be little advantage in making other than a forced plane landing for light repairs anywhere upon the inland ice.

POTENTIAL BASES FOR DEFENSE

In view of the difficult ship navigation problems surrounding Greenland, its value as an outpost of the United States lies mainly in the possibility of establishing bases upon its borders for aircraft and for destroyers and submarines. These would prevent occupation of the island by an enemy, serve as a "listening post," and be in a position to attack enemy shipping along main sea routes between Europe and America. Several of these routes are a few hundred miles distant from the southern tip of Greenland. Such a base for destroyers and submarines could be established in one of the fjords near Julianehaab in extreme South Greenland (Fig. 2). These southern fjords, unlike others in Greenland, can be entered by surface ships almost, if not quite, throughout the year.

Except for a very few places which will be referred to, airplanes with wheel undercarriages could not be used in Greenland, but seaplanes with ski replacements during the winter season could be used, especially within or near the fjords of South Greenland. For such planes the larger lakes supply the best landing fields, whether frozen or open. There are also near the heads of fjords stretches of water surface which are overlaid by comparatively dead air even during storms, and which in consequence remain frozen during much of the winter season. Two Moth planes fitted with pontoons and skis were actually flown near Angmagssalik on the east coast during all months of the year 1930–1931 by the British Arctic Airroute Expedition stationed there. Moreover, the modern surveys carried out by the Danish Geodetic Institute and the extensive ones by Dr. Lauge Koch in East Greenland have made use of such planes (see Fig. 2).

The Arsukfjord in latitude 61° 20′ N, longitude 48° 20′ W, though in extreme South Greenland, open for the most part throughout the year and sometimes used in flights between Europe and America, is not to be recommended. This fjord is narrow with steep walls, and low stratus clouds with great precipitation prevail from December through March. Visibility is very poor, and the sun is seldom seen from late December to middle February, though on an open sea the hours of daylight through this period would be from seven to eight hours. Moreover, bergs calve from the glacier at the head and produce rough ice upon the fjord.

The best location for a naval base would be in the vicinity of Julianehaab (lat. 60° 45′ N, long. 46° 5′ W), which is about 100 miles east of the Arsukfjord. At Julianehaab there is located a colony of Eskimos with European officials and the most powerful of the Greenland long-wave radio stations.

Sangmissok (lat. 60° N, long, 44° W), which is north of and twenty miles inland from Cape Farewell, lies at the center of a star of intersecting fjords, and is strategically the best located position for another seaplane base. It lies about 120 miles east southeast from Julianehaab.

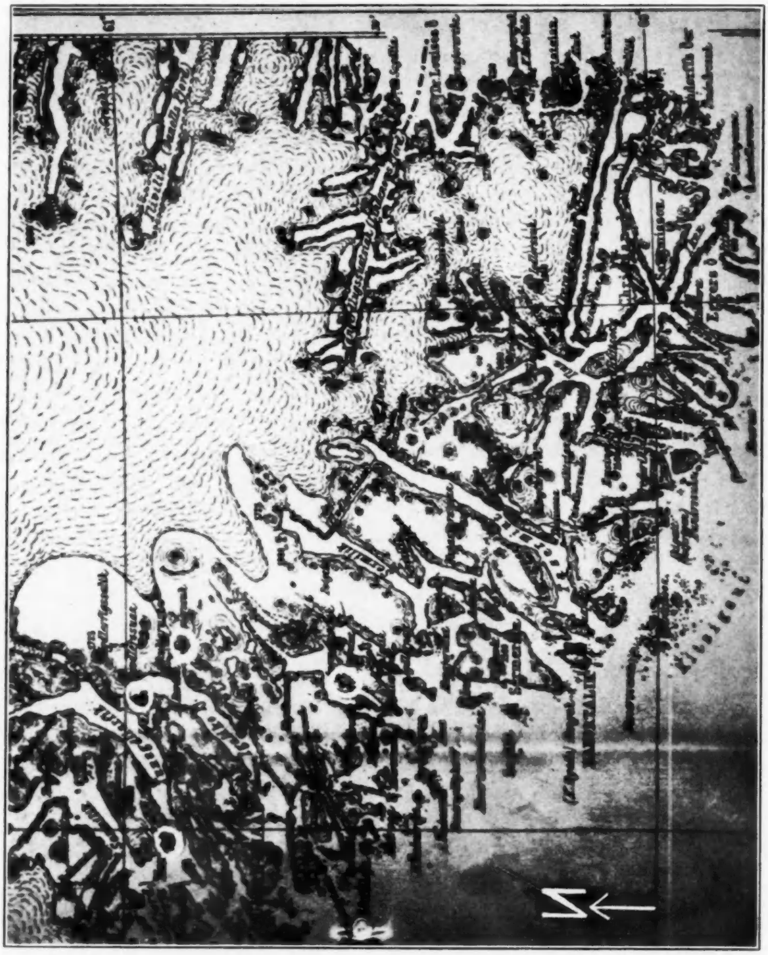
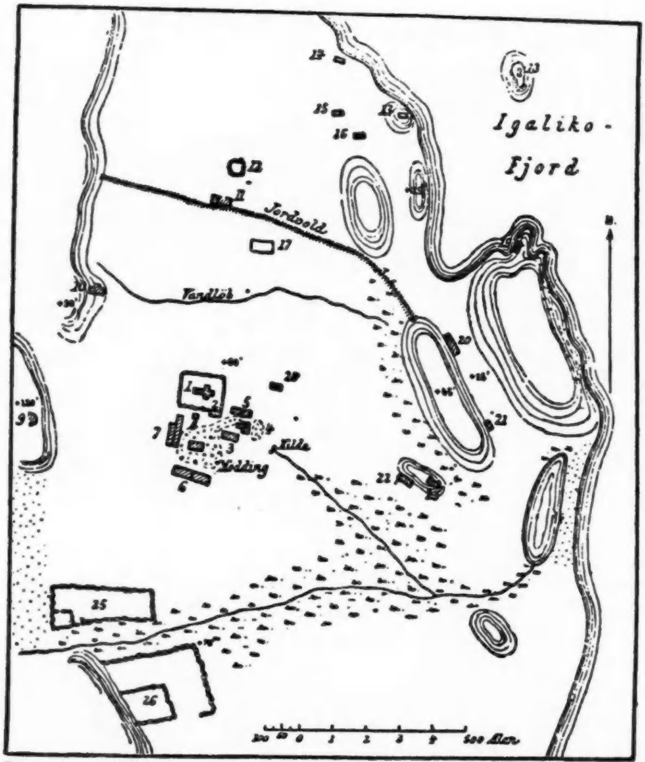


FIG. 2.—Map of the region surrounding Julianehaab in extreme South Greenland. The flat areas which might be used as landing fields for airplanes are located at Narssak, Igaliko, Kagsiarssuk, and Sletten (Danish for the plain), which here appear upon the map encircled by rings. (From an official Danish map of 1921.)

The most strategic position for the location of an airport is in extreme South Greenland, the Julianehaab district, since the area is close to the great circle route between Cartwright—in Labrador—and Iceland, and only a few hundred miles to the northward of a great circle route from our Newfoundland bases to Iceland—it is about 900 miles from each of them. It is in this general locality also that the naval station should be located, since the port has for Greenland the unique quality of remaining accessible to surface ships practically throughout the year. When the loose pack lies off the port, floe ice is carried by the fierce southeast storms, as well as by the tides, far into the fjords and may at times jam within them so as to stop navigation between Julianehaab and the hinterland, but usually this is not for long periods even during the winter. On the other hand, the katabatic winds of the storms issuing from the lobes of the ice cap to the northward and eastward (see map of Fig. 2) may clear the fjords within the span of a few hours. As already mentioned, the stretches of the fjords near the glaciers at their heads usually remain frozen throughout the winter, for the reason that the high velocity of the storm winds causes them to override the air close to the steeply rising glacier surface. One may here stand on the frozen fjord surface during a calm and hear the roar of the tempest far above one's head. Within the fjords but farther out toward the sea the ice seldom attains to any great thickness, for the average air temperature during the winter months is above the freezing point of the water. Moreover, the tides with a range up to twelve feet keep the surface ice in motion up and down between tide cracks which separate it from the stationary shore ice on either side. The wind within all steep-walled fjords blows lengthwise of the fjords as though it were within a tube, either in one direction or the other according to that component of the wind above the fjord which is parallel to its length.

There are at least three localities within the hinterland of Julianehaab where are found nearly level land areas large enough for landing fields, and these all lie close to the shore but a few feet above tide water. Hence no road building would be necessary for bringing in equipment and supplies (see Fig. 3 and Plates I, A and I, B). For a number of years certain meteorological data have been collected from these fields.[4]

[4] Though Julianehaab has long had a second-class weather station (Nanortalik) and a third-class station (Julianehaab) within the Julianehaab district, beginning in 1932 or the year following that of the German Greenland Expedition, three additional third-class stations were set up by the Danish government within the district, and each was on one of the three possible landing fields that are known (Narssak, Igaliko, and Sletten). Beginning in 1936 another station (Sydpröven) was added to give the conditions off these stations upon the coast (see Meteorologisk Aarbog, 2den Del: Grönland, Copenhagen).



By courtesy of M. Clemmensen

FIG. 3.—Map of the plain at Igaliko in the Julianehaab District (after a survey by Captains G. Holm and D. Bruun).

It is of special interest to note from these recorded observations that these prospective landing fields are practically fogless except during the late summer months, with a total of foggy days for the year generally less than twenty. Two other conditions of first importance should be noted. The pattern of the great fjord system is on a scale seldom approached elsewhere in the world. With good visibility the aviator approaching Greenland through or over the prevailing fogs offshore can find his position. As he comes out of the fog, the great white masses of the two lobes of the ice cap to eastward and westward are unfailing in giving him his general position, and the pattern of the different fjord districts gives him his exact position.[5]

[5] The Rockford flyers who were in 1929 en route to the Mount Evans landing field,

Pl. I, A. Landing field for airplanes near Mount Evans, base of the University of Michigan expeditions. The landing field is in the middle distance, and gasoline is seen on its way to the field. (From a photograph by Professor L. M. Gould.)

Pl. I, B. Portion of a plain at Igaliko at the head of the Igalikofjord northeast of Julianehaab (Meddelelser om Grönland, Vol. 47, p. 327.)

On the southwest coast of Greenland there are fortunately two possible landing fields a few miles only apart suitable for planes with wheel undercarriages, which have a much greater radius of action than seaplanes (Plate I, A).[6] This field is almost free from fogs, as is shown by two years of meteorological observations made at the University of Michigan station of Mount Evans, which is only six miles distant. It is also fortunate that this locality and the other one which has been located a few miles away together obviate the danger from similar enemy planes which could operate from any near-by station. This location near the head of the Söndre Strömfjord could be made attainable from the sea by surface ships, and its distance from a station on the North American continent in Labrador is such that it is attainable by pursuit as well as bomber planes.

On the east coast of Greenland there appears to be only one area which affords possible landing fields. This is that of Jameson Land and Depot Island in Hurry Inlet (Nathorst Fjord) near the north entrance of Scoresby Sound. The locality is well known to the Germans, who established a meteorological station in Jameson Land during the year 1930–1931, at which time they prepared a full series of meteorological ground observations and aerological studies as well. The great handicap of this locality regarded as an aviation base is that it is accessible by surface vessels for so short a period during the late summer. Its position is about 400 miles from airfields in Iceland, and 900 miles over the ice cap to the landing fields near Mount Evans, which in turn are separated from Cartwright—in Labrador—by another 900 miles. From our Newfoundland airports, the Mount Evans landing fields are distant about 1300 miles.

It is possible that landing fields could be located in the area to the northward of Scoresby Sound, especially near Mackenzie Bay, in spite of the difficulties of approach from the sea. In any case, the locality could be made use of to advantage for meteorological forecasting purposes, and northerly stations on the Greenland west coast could be similarly made use of. Such stations, of late manned by native Greenlanders (half-breed Eskimos), have long been utilized by the Danish Meteorological Bureau, and in later years in combination with the German station at Hamburg for preparation of

were carried nearly two hundred miles off their course to the southward, and came out of the fog over the little fishing hamlet of Fiskernaes. The fjord in that district they took to be the Söndre Strömfjord, but when in flying along it they found it only twenty-five miles long, they took out the map I had given them and were able to find their true position from the pattern of the fjord.

[6] A map of the head of the Söndre Strömfjord showing the location of Mount Evans and of the landing field for airplanes in the northeast and on the shore of the Tidal Flat, appears as Figure 7, on p. 9 of vol. I of W. H. Hobbs: *Reports of the Greenland Expeditions of the University of Michigan, Part I, Aerology,* 1931.

synoptic weather charts. These charts, however, have given very misleading results, perhaps in part due to the fact that the meteorological stations were located within the fjords, where wind direction particularly, and also some other meteorological elements are quite different from what they are in higher levels. As an instance, the University of Michigan Expedition was on one occasion coasting southward on the west coast of Greenland, and in a terrific storm took refuge in the little harbor of Inugsugtussok, where we were soon joined by others and generally fishing smacks likewise in distress. Fishing captains with many years of experience off this coast reported to the writer that this was the worst storm in an experience of seventeen years, but it was noted later that the pressure chart for the district indicated a nearly flat surface.

University of Michigan,
February, 1941

Alaska in Relation to National Defense

JOHNSON E. FAIRCHILD

THE VALUE OF THE TERRITORY

Alaska occupies a strategic position as the great northwesterly buffer of the American sphere of influence. Potentially, it controls the North Pacific Ocean, as Alaska and its Aleutian Island chain form practically the northern boundary of the Pacific. Furthermore, the Great Circle route from Seattle to Yokohoma crosses the Aleutian Islands. This route is 1392 miles shorter than by way of the Hawaiian Islands and the distance between bases is much shorter also. From a practical point of view, Alaska may be considered an insular possession, because the only contact with the rest of the world is by water and by air.

It is conceivable that this northern region might be looked upon with envy by vigorous nations with large populations and small resources. Alaska, with 586,400 square miles of territory, is equal in size to one-fifth of the area of the United States proper. The Territory has a population of only 74,000, or about one person in every seven and a half square miles, and of that number, approximately one-half or 38,000 are white. According to the 1940 census, there are only 8,000 males between 21 and 35 years of age in the entire territory. Dividing the population into regions, the scarcity is even more apparent, because about one-third of the number lives in the southeastern section of about 35,000 square miles, and thousands of square miles in interior Alaska remain practically uninhabited.

Obviously, a region which produces between 40 and 45 million dollars worth of fish, about 20 million dollars worth of gold, and several million dollars worth of copper, minor metals, and furs yearly and which has potential reserves of oil, coal, water-power and lumber resources, would be a prize for almost any country. The very fact that it is so comparatively undeveloped and underpopulated, makes it seem that much more desirable and easy to take.

Vilhjalmur Stefansson is a great believer in the possibilities of Alaska, as was Alfred H. Brooks, who has said: "In fact we may confidently expect that the time will come when Alaska will support a population of 10,000,000 people."[1] A speech by the Honorable Anthony Dimond, "Alaska, Fact and Fiction," sums up the point of view of the Alaskan advocates:[2]

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[1] Brooks, Alfred H. The Future of Alaska. *Annals of the Assoc. of Amer. Geogr.*, December, 1925, p. 163.

"A comparison of Alaska with Sweden, which has a population of 6,000,000 is equally favorable to the Territory. Sweden has an area of 173,550 square miles; its farming and grazing lands do not in area exceed one half of that of Alaska, and yet its agricultural population comprised approximately 2,700,000 people. Sweden has in reindeer pasture about 40,000 square miles, as against 240,000 square miles in Alaska; it has in woodlands 2,000 square miles as against 181,000 square miles in Alaska. Sweden, like Finland, has nothing in the way of natural gold reserves, and its copper reserves are very small indeed as compared with the very large copper reserves of Alaska. It may be that in iron reserves Sweden surpasses Alaska, because we find its iron resources listed at 442,000,000 tons, while no survey has ever been made, so far as I am aware, of the iron reserves of Alaska. We know Alaska contains considerable iron, but it would be rash for anyone to try to compare it with Sweden in that respect. Alaska has large deposits of marble, Sweden little. Alaska, so far as known, contains 40 times as much coal as Sweden. Alaska apparently has large reserves of petroleum, and Sweden is entirely without this resource. Sweden surpasses Alaska, but not very much, in total water power, the figures being Sweden, 3,500,000 horsepower, and Alaska, 2,800,000 horsepower. The fisheries of Sweden, although extensive, do not amount in value to half of those of Alaska. Now, in this connection let me point out once more that Sweden and Finland lie in the same latitude as Alaska. Finland touches the Arctic Ocean on the north and the Gulf of Finland on the south, and it is cut off from Sweden by the Gulf of Bothnia. Both of these countries are far enough removed from the Atlantic Ocean to be measurably deprived of the warming and moderating influence of the Gulf Stream. The climate of these two countries is, taken by and large, approximately the same as that of Alaska. So when I conclude, as I do, that the Territory of Alaska is capable of supporting in comfort a population of several millions, I am not drawing at all upon my imagination but basing it upon what has been done in the old world and upon an impartial consideration of geographic and scientific facts."

Although there are other (and opposed) points of view about the possibility of increased settlement in Alaska, nevertheless the wealth of the Territory at minimum valuation might easily attract a poor nation. Hence, Alaska ought to be defended against invasion by a foreign power seeking territory and natural resources. It ought also to be defended as a strategic region in any war for position in the North Pacific basin.

POSSIBLE SOURCES OF ATTACK

The word defense presupposes an attack, and the question arises, attack by whom and by what means? In the first instance, the case of the invasion of Alaska, there are only three countries which could conceivably be powerful enough or in a position to do this, namely Germany, Russia, and Japan.

Germany, with its apparent idea of world dominance, must always be considered, but can probably be ruled out as an immediate invader for obvious reasons. Soviet Russia, which is nearest to Alaska, has perhaps the greatest claim to the territory, but the least need of it. The U.S.S.R. might perhaps claim that Alaska, once the property of the Russian people,

[2] *Congressional Record,* 74th Congr., 2nd Session, May 21, 1936. p. 5.

had been sold by the Czar without the interest of the Russian people at heart, and therefore the sale of the Territory to the United States was, as far as the Russians themselves were concerned, illegal, and that the wealth of Alaska actually belongs to Russia. On the other hand, the fact that it would be difficult for Russia to defend should she once capture it, plus the fact that Russia already has too much similar territory, makes it seem much more logical and inexpensive for the U.S.S.R. to develop its own Arctic and sub-Arctic regions, as it is doing to a great extent, rather than to risk the outcome of a war with the United States.

The third country, Japan, has the greatest need for territory and resources. Alaska would be very valuable to Japan and it is probably true that Japanese ships have already been taking American salmon and seals and that Japanese naval officers have been charting the Alaskan waters. But there are several factors which must be considered so far as an immediate invasion of Alaska by the Japanese is concerned. The first one, obviously, is that Japan is at present engaged in a long and exhausting war with China. Should Japan lose that war, she would not be able to invade Alaska. Should she win, she would certainly need time to consolidate the mainland empire, which would supply some of the raw materials to be gained in Alaska; and in the third place, the Japanese, to the best of our knowledge, have but very little training and experience in the development of northern exploration or Arctic fighting. The inference must be drawn from their past activities that the Japanese, if at all possible, would prefer to expand southward rather than northward. So much for the danger of the immediate invasion of Alaska for resources or territory.

CRITICAL DEFENSE POINTS

However, should Alaska be invaded, it must be pointed out that to control the entire interior territory, only three key positions would have to be taken—Seward, Valdez, and Dutch Harbor (Fig. 1).

Seward is the terminus of the one major railroad, the 470-mile Alaska Railroad. This line is the only year-round land communication with Fairbanks and the great mass of interior Alaska, and all types of supplies and shipments travel over it. Control of the port of Seward would bottle up interior Alaska during the winter. Anchorage is not of much use as an outlet port because of the huge tidal bore, second only to that in the Bay of Fundy.

During the summer months the Richardson Highway (371 miles long) from Valdez to Fairbanks is open and could easily be controlled at Valdez. Valdez is in a famous snow pocket and receives something like ten feet or more of snow in the winter.

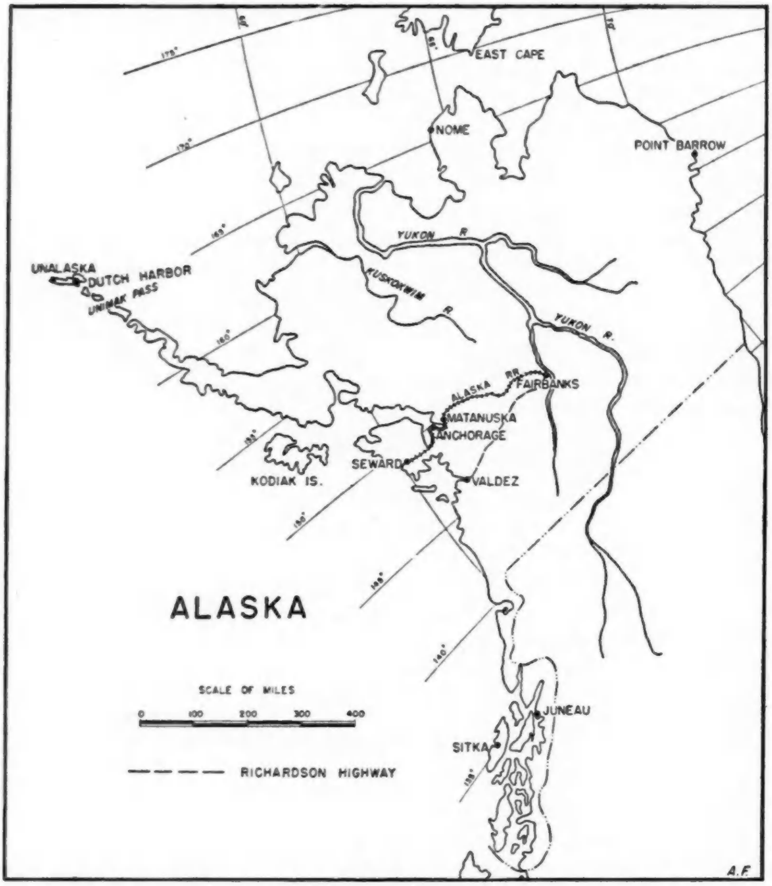

FIG. 1.—Principal places mentioned in the text.

The only northwestern port, and a very poor one at that, Nome, is icebound throughout the winter months and in summer could be controlled by a base on the Aleutians near the famous Unimak Pass. So the bulk of Alaska could be controlled in the winter from Seward and in the summer by the addition of Valdez and Dutch Harbor. Until recent months, Alaska was practically undefended, and the Governor of Alaska, Mr. Ernest Gruening, has said that Alaska could be captured by twenty parachute

troops.[3] Though this is of course an exaggeration, nevertheless, the inference was generally correct.

As pointed out above, so far as the immediate situation is concerned, Alaska is not likely to be invaded for either territory or resources, so that in considering defense, the real point is the strategic value of the territory. The defense of Alaska in this case must be considered from the point of view of the several distinct geographical units. The interior region is of little strategic importance, while the less economically valuable Aleutians are of great strategic value, as is also the coast line of southeastern Alaska. The Aleutians, and to a certain extent the Alexander Archipelago chain, must be considered as the northern base for any major operations in the North Pacific. The long spearhead of the Aleutian Islands should act as a defense of the northern flank of our strategic Pacific triangle—Panama, Honolulu, Seattle. Adequate bases for naval and air corps units along southeastern Alaska and the Aleutians would ensure security from attack in the area between the Hawaiian Islands and the Aleutians, or virtually all of our northern Pacific coastline, by giving us a strong flank. So far as attack is concerned, the Aleutian Islands would give the United States stepping-stone bases leading directly towards the Kurile Islands and the main chain of the Japanese Empire. On the other hand, should the Aleutian Islands and southeastern Alaska fall into enemy hands, the Pacific Coast of the United States would be in danger because this sheltered northern coast would be an ideal pathway for submarines and small enemy raiders to sneak down the fjord-indented, island-fringed coast and harass our northwestern coastline. Thus, the Aleutians and the Alexander Archipelago could be used much as Germany planned to use the very similar coastline of Norway. There is today a Japanese naval base at Paramushiro, only 700 miles from Attu, at the end of the Aleutian Chain. There is a Russian base at East Cape, only 56 miles across Bering Strait, and another Russian base at Komandorsky, only 250 miles away.

PREPARATIONS FOR AND PROBLEMS OF DEFENSE

Apparently, as the situation stands today, operations in the Alaska region would be largely naval and aerial. Until this past year, the defense of Alaska has consisted of several hundred infantrymen at the Chilcoot barracks with only a few patrol planes, and no artillery, and a small base at Unalaska. The Alaskan claim that the defense of their valuable territory has been neglected is true. The immediate plans for the defense of the Aleutians and southeastern Alaska call for the development of naval bases:

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[3] Franklin, W. M. Alaska, Outpost of American Defense. *Foreign Affairs*, October, 1940, p. 247.

at Kodiak Island to cost 9,800,000 dollars; at Sitka to cost 2,939,000 dollars; and the enlargement of the base at Unalaska.

In connection with aviation in southeastern Alaska and the Aleutian Islands there are peculiar difficulties and problems. Perhaps the greatest handicaps are fog, storms, and cloudy weather. There are more than 200 cloudy or foggy days a year, 100 to 150 inches of rain, and in places 100 inches of snow a year. In the Aleutian district, there is dense fog during 15 to 25 percent of the winter. Also, the lack of level land limits all air operations to seaplanes or carriers, at the mercy of the uncertain weather. The lack of settlements and emergency landing fields is also a factor. The high, rugged, mountain masses also offer great handicaps. Unusually strong local winds, particularly violent antitriptic winds in the vicinity of the mountains, such as the *taku* inland from Juneau, and peculiar local storms present tremendous problems to fliers. In the Gulf of Alaska region, the famous "willy wogs" are most feared. These winds, apparently connected with the low pressure areas in the Gulf of Alaska, have reputedly tossed airplanes around in the air like chips in the sea, turning them over and over and putting them completely out of control. Over the Bering Strait cold fogs that cause a layer of ice to form on the planes are a constant menace. Of course the difficulty of radio communication and beam and instrument flying due to magnetic and electrical (aurora borealis) disturbances are well known, so that flying in this northern district requires a technique different from that being developed in the United States. Joe Crosson, one of the famous Alaskan pilots, claims that it takes at least six years of flying in Alaska to train pilots to cope with the peculiar conditions.

In the interior, progress is being made on new Army bases at Anchorage and Fairbanks. Elmendorf Field at Anchorage, to cost 12,734,000 dollars, will be the major Army base in Alaska. The climate is milder and flying weather is better than at Fairbanks. Furthermore, Anchorage, although not a terminus, has the yards and shops of the Alaska Railroad and is near enough either to Fairbanks or Seward to make it easy to shift troops either to the coast or to the interior. The near-by Matanuska valley agricultural district might, to the mutual benefit of both projects, be able to supply food for the camp. About 6500 troops have been sent to Anchorage. Ladd Field at Fairbanks, to cost about 4,000,000 dollars, is being developed as a sub-Arctic experiment station which will enable the Army to work out the problems of flying and fighting in the north.

Local floods in spring and soft ground in summer in the interior of Alaska make it necessary to use very expensive reinforcements on all airplane runways and hangars. There are only two or three snow-free months a year and the extreme cold of −40° to −60° F., and a 100-day period of

below zero temperatures make all ground operations difficult. Precision instruments, gun sights, engines, oil, and men are all affected. Just to mention one of the minor difficulties of attempting to turn Alaska into a great air base, Major General H. H. Arnold, Chief of the Army Air Force, claims that there are not available 250 suits of clothing necessary to outfit fliers for work in Alaska.

The greatest advantage in the development of Alaskan land defenses would be the construction of that link of the Pan American Highway which would connect Alaska, British Columbia, and Seattle by motor road. There are about 1200 miles to be constructed, and the American Commission wants this road to go as close to the Pacific as possible so that coastal towns could be tied in at a later date. The drawback of this plan has always been that the greatest expense of road-building would fall on Canada and the greatest advantage would fall to the United States. Some people have advocated that the United States attempt to get a corridor through Canadian territory in return for American aid to Great Britain in the present war, thus giving us a land tie to our northern possession. Of course the engineering difficulties and the expense of building such a road would be tremendous. It has been estimated conservatively that 15 to 25 billion dollars and three years time would be necessary to complete the highway. Owing to the shortness of the working season and the expense of importing all equipment, in all probability the expense would actually be much greater than estimated. After the road was completed, its great drawbacks would be the high cost of maintenance, the high price of transported gasoline, and the fact that large sections of the road would be closed during the winter season.

Alaska was the meeting place, during the seventeenth century, of Spanish, Russian, British, and later of Colonial American influences. Although there were many different reasons for the withdrawal of the Spanish and the Russians from this sphere of influence, the real reason may probably be summed up in the phrase "lack of colonization." Today, Alaska is in somewhat the same condition,—underpopulated and undergoing exploitation. It would seem that for the real future defense and development of the area, some schemes of population and economic development are necessary. There are difficulties in the way of such action: the extreme cold of winter, plus the monotonous isolation, the Arctic lethargy, and the virtual cessation of economic activity above ground; in the summer months the great swamps and mosquitoes of the Yukon-Kuskokwim basin, the acid soil, the limited market for farm produce, the high cost of transportation making prices prohibitive. It must also be remembered that increasing the population would rapidly cut down the supply of game for food. Perhaps

the partial failure of the Matanuska Valley experiment has taught some lessons in Alaskan colonization. However, roads, landing fields, and especially meterological stations, and perhaps an effort, such as the Russians have made, in sub-Arctic colonization are indicated, because Alaska's geographical situation gives it a unique location in the Great Circle route to the Orient and Europe from the northwestern United States. It is conceivable that in the future commercial air routes will be flying to Europe and the Orient across the North Pole, thus making towns such as Fairbanks and perhaps Point Barrow of great significance so far as commerce and air strategy are concerned.

Hunter College,
March, 1941

Petroleum Utilization in Peacetime and in Wartime

JOHN W. FREY

PETROLEUM IN THE FIRST WORLD WAR

Warfare through the ages has made but few fundamental changes; from stone implements to metals, especially iron and steel, from manual percussion to explosives and from communication and power derived from humans, animals and the wind to electric communication, and power through the release of hydrocarbon energy. The development in the application of radio and mechanisms powered with oil burning internal combustion motors have been the most outstanding technologic changes in direct military operations in the past two decades.

Military opinion concerning the function of petroleum during World War One is that it contributed greatly toward the victory of the Allies. Several years before the war a few ships were burning oil but during the war the Allied navies were largely converted from coal- to oil-burning, as was also a considerable fraction of the larger vessels of the merchant marine. Gasoline-consuming airplanes made a spectacular record in reconnaissance and got under way in aerial bombing. Oil burning Diesel powered submarines were active. Tanks for the first time entered the war picture and gasoline powered automobiles played an increasingly important part from the taxi and delivery-truck trek across Flanders in August 1914 to the motorized lines of supply four years later. Gasoline gave the army greater mobility and consequently an advantage, but it was fuel oil (including Mexican) referred to in the often quoted statement, "The Allies floated to victory on a wave of oil."

PETROLEUM BETWEEN TWO WARS

The United States in 1914 did not have a so-called "automobile economy." Many of us have seen that economy evolve, and accept it without proof; but to make the present structure and the function of petroleum stand out in clearer relief it is desirable to indicate the position of the older grade line (to borrow a surveyors' term).

Commercial transport in 1914 was the problem of the railways and boats for all but local delivery; there were no inter-city highways of much consequence and there were no commercial airways. Farmers and village people

had not been bothered enough by autoists hunting their way to set up road markers. One may recall the typical guide-book directions: "at 25 miles turn right at crossroad with red barn on S. E. corner, continue to end of road, turn left, immediately after crossing railroad tracks bear right on diagonal road to village of Beaver Brook." That was in about year twenty-five of our automobile history, when there were approximately $1\frac{1}{4}$ million cars in this country.

On the farm the use of small gasoline engines was increasing rapidly but tractors for field work were uncommon and the small tractor did not exist. Airplanes were still in the "crate" stage and were powered with low compression motors. Residual fuel oil, although generally of better quality than it now is, was used almost entirely for heavy heating and power jobs. The distillate between residual fuel oil and gasoline was still essentially a lamp oil and Diesel and higher grade heating oils were of little significance. Gas oil, however, was of considerable importance for the enrichment of manufactured gas. At the beginning of the World War kerosene was losing position to gasoline, but in volume was still the leading petroleum distillate.

The United States during World War One developed rapidly in automotives. In 1913 the total automobile registration was 1,259,000 which by 1918 had increased to 6,147,000. In 1913 there were only 63,800 trucks in this country but by 1918 the number had risen to 525,000.

Probably as a consequence of the increase in automobiles, good road agitation resulted in the recognition of the importance of highways to the nation and since 1916 Federal aid has been extended to the States for the construction of a nation-wide network. The Federal contribution to highway construction totals about $3\frac{1}{2}$ billion dollars, which, combined with expenditures of the States (the construction is handled by the States), totals more than 9 billion dollars. The Federal tax on gasoline and lubricating oil contributed, if by inference that was its purpose, something less than 2 billion of the $3\frac{1}{2}$ billion dollars for improved highways.

The highways which the Federal and the State governments have built were built for automobiles and effective utilization of them is now dependent upon petroleum. Improved highways have made for a greater number of automobiles, greater speed and more mileage per car, with a consequent increase in the rate of using up our petroleum reserve. Cracking has increased the yield of gasoline and at the same time has made a more effective product for the higher compression motors that are not only lighter but consume less fuel per unit of power generated. Probably equal to the conservation by cracking are the smooth hard roads that have reduced the fuel consumption per ton mile.

During the past twenty years the automobile has been an important factor in population shifts. While the population distribution on farms and in small towns has been profoundly affected, probably the most striking population change has been in the metropolitan areas. These have increased, but their satellite cities and suburban areas—in other words the peripheral zones—have increased much more rapidly than the central cities themselves. Automobiles, plus highways, plus gasoline figure strongly in the recent population and industrial location equation; consequently an effective economic mechanism requires continuous energizing by petroleum products.

CONSUMERS OF PETROLEUM TODAY IN THE UNITED STATES

Today about 60% of the energy for transport in the United States is derived from gasoline and fuel oils; this includes not only 30,000,000 automobiles but also commercial airplanes that now fly more than 100 million miles a year; locomotives that in certain areas—notably the South and West—burn fuel oil only; all the highspeed streamliners; and the American merchant marine, 93% of which depends upon oil.

All parts of American industrial and social life have become affected by petroleum. The food supply of this country in peace or in war is closely linked with motor fuel. About 1,800,000 tractors are used in farming. About 41% of all the automobiles in America is on farms or in towns under 2,500 population. The delivery of milk and other agricultural products in cities by automobiles passes without note except by light sleepers. Trucks haul from the farms to *central* markets 52% of the cattle, 68% of the hogs, 65% of the live poultry and 40% of the fruit and vegetables.

Space prohibits even an outline of the cultural relationships affected by petroleum and in turn their relationship to industry but certainly education is an example of this close association and the 86,000 school buses carry 3,742,000 children to schools generally different from those that were located with respect for the distance children could readily walk.

While many manufacturing operations in war industries are directly dependent upon petroleum and its products there is a risk of overemphasizing certain new or spectacular applications to the point where one may lose the scale of petroleum in total industrial operations behind the lines, and likewise the integrating effect of petroleum upon industry. Of course it must be obvious that machinery and lubricating oils and greases from petroleum are part and parcel of manufacturing. Chemists and engineers have found many important and direct applications for petroleum to war industries, among which are synthetic rubber, benzol and toluol. Petroleum is rich in compounds that are susceptible of chemical manipulation but the percentage volume of special products is relatively small. The big job for

petroleum is to keep our industrial operations as nearly normal as possible and to meet the increased demand for fuel and transport caused by industrial acceleration.

Petroleum when refined yields principally gasoline, kerosene, gas oil and distillates, residual fuel oil, lubricants, wax, coke, asphalt, road oil, and still gas. One hundred gallons of crude oil when refined yield, on the national average, about 44 gallons of gasoline, 25 gallons of residual fuel oil and 18 gallons of lighter burning oils; all the other products, including the losses, amount to about 13 gallons. It therefore appears that petroleum exerts its major influence through two groups of products, motor fuel and fuel oils, approximately equal in volume.

The domestic consumption of fuel oils, in which I have included range oil, gas oil, distillates, and residual fuel oil, totalled about 500 million barrels in 1939. The largest single use was for heating, which totalled about 176 million barrels or 35.7% (the bulk of this used in heating 1,750,000 homes). Boats used almost 80 million, or 16.1%, railroads about 63 million, or 12.8%, gas and electric power 32 million, or 6.5% and the Navy, Army and Coast Guard between 12 and 13 million, or 2.5%. It appears reasonable to believe that fuel oils will not undergo radical changes in use in war industries, although probably the acceleration in all uses will not be equal. A comparison of the trends in the demand for motor fuel and heating oils reveals that heating oil consumption has for several years been moving upward much more rapidly than motor fuel; hence internal adjustments in the petroleum industry may be necessary if anticipated demands are to be met.

About 89% of the domestic motor fuel consumed is used by motor trucks, buses and passenger automobiles. The industrial employment of motor vehicles is widely diversified, from the movement of goods within the factory to the determination of plant sites with respect to areas of supply of materials, labor, markets, and the integration of manufacturing industries with each other. As it appears to be imperative to use the mechanism we have as a base for war industries, it is necessary to keep up the supply lines that exist and to eliminate tight places. A country engaged in supplying military materials should not dissipate its energy by major industrial and population shifts.

WARTIME NEEDS FOR PETROLEUM

War industry, like the Army and Navy it supplies, is, as far as materials go, dependent upon food and supplies which in turn have a place value determined by speed and the cost of transportation. Petroleum in war industries should be thought of in its major role, a vital fluid for the energizing and the integration of American industry and life.

National defense means preparation for war; war today means total war, that is, war that affects all the people and operations of industry, not just a military operation by the Army and the Navy without mobilization behind the lines. Much of the comment on the preparedness of the petroleum industry for national defense has emphasized the requirements of military operations as such: the need for aviation gasoline, fuel oil and Diesel oil for the Navy, synthetic rubber as a substitute for an exotic strategic material, and certain chemicals of importance to the fighting forces. Many have pointed with pride to the record of the oil industry in World War One; many speakers contend that military requirements many times larger than peacetime requirements can be readily met. The general tenor is that the oil industry is prepared to meet any demands placed upon it.

Before accepting such statements at par, the demands for petroleum that are likely to be made by industrial and domestic consumers should be very carefully considered. Sight should not be lost of the magnitude of the basic demand. For instance, the Army, the Navy and the Coast Guard used in 1939 between 12 and 13 million barrels of fuel oil or 2½% of the total. If military operations were to increase that figure 3, 4, or 5 times, the amount would still be less than was used by the railways in 1939. In that year they consumed 13% of the fuel oil.

Probably no other petroleum derivative is of greater military importance than aviation gasoline. The estimated domestic consumption of that product this year is about 5 million barrels, or less than 1% of the estimated total demand (590 million barrels) for motor fuel. From a statistical point of view the gasoline situation would appear to be simple, as the demand for aviation gasoline would have to increase something like 12 times to equal a one-tenth increase in the demand for other types of motor fuel. Parenthetically a 12-times increase in the demand for aviation fuel during the next year is unlikely, but a 10% increase in motor fuel demand is probable. The aviation gasoline problem, is, however, not as simple as it seems. The correct use of existing refinery facilities plus the construction of additional plants to meet increases that can be calculated well in advance should avoid any trouble as far as refinery capacity is concerned. But strange as it may seem, tightness may occur where it is generally considered that we have no problem, namely in the sufficiency of aviation types of crude oil. Concerning this it is only necessary to point out that the content of aviation gasoline in most of our crude oils is extremely low, and that much of our crude oil is not suitable as raw material for aviation gasoline by refining processes now commonly in use.

Although comparable figures on United States consumption of petroleum products at the beginning of World War One and in 1940 are not

available, all facts show a small oil industry in 1913 and one of great magnitude today. In 1913 the production of petroleum in the United States was about a quarter of a billion barrels; that included domestic consumption and exports. Today the annual domestic consumption is rapidly moving toward a billion and a half barrels. This difference is also revealed in refinery capacities, which in 1913 were about a quarter of a million barrels daily and this year are in the neighborhood of 4 million barrels daily.

The demand which was imposed upon the oil industry during the World War and the period immediately thereafter caused a high percentage increase because of the introduction of new uses in military operations: especially the change from coal to oil by the navies, a rapid increase in automotives, and in increased industrial consumption of fuel oil, due not only to war activities but also to coal mining and transportation difficulties. Today the ordinary domestic demand is so large that a relatively small percentage increase causes significant changes.

RELATION OF WAR NEEDS TO PEACE NEEDS

Regardless of whether one likes or dislikes the current pattern of American life, the fact remains that the triple alliance of automotives, highways, and petroleum in a little over two decades has strongly influenced or possibly produced a new culture in this country. All the components of that element of our life called industry make demands upon petroleum. Industries engaged in the manufacture of war materials, except for a few special products, probably will do little to change immediately the pattern of consumption, although there is a strong likelihood of considerable acceleration.

The indirect effect of war's industrial activities on petroleum promises to outweigh by far the effect of direct military demands. Vital as petroleum is in direct military operations it is unique as an energizing and integrating force in our civilian culture. An intelligently directed and well coordinated petroleum industry, a desired ultimate goal in peace, is a necessity in war. Placing the emphasis on direct military operations in calculating the effect upon petroleum may create a feeling of false security and at the same time conceal the function of petroleum in our industrial economy. Regardless of all the assurances that the petroleum industry is prepared to meet any demands placed upon it, nothing should stop the hunt for such weak spots as may exist in order that they may be corrected. Thus we shall maintain the highest possible efficiency in our lines of supply.

Washington, D. C.
January, 1941.

Mapping the Changing World: Suggested Developments in Maps

S. WHITTEMORE BOGGS

Within the brief period of history in which the United States has expanded from the Atlantic to the Pacific, inventions and industrial development of the so-called western civilization of Europe and America have changed the world more than we yet perceive. Among the factors that are producing fundamental changes, phenomenal increases in the speed of travel and communication, and decreases in transport costs, are conspicuous. It is as if a quiet game of croquet had been transformed into a stirring contest of polo, with its mounted players covering a greatly enlarged field at high speed, while the game was yet in progress. By the happiest of coincidences for this country, these factors have made possible the integration of a single nation nearly as large as Europe. Conversely they appear to have made impracticable in Europe the development along highly nationalistic lines of numerous small states.

Largely as a result of the new techniques, the contemporary contrasts between adjacent areas throughout the world, in population density and in living standards, for example, are greater than ever before in history. The metamorphosis of some regions within a few decades has been extraordinary. It is therefore highly desirable to represent on maps the factors which are associated with the changing world, in so far as they lend themselves to such visualization, if we are to understand when and where and how these forces have operated. The preparation of more effective maps, as an aid to comprehension of current world problems, will require chiefly research in finding pertinent information that may be embodied in map form, and cartographic skill in presenting it. An attempt is made in this paper merely to suggest certain improvements that may be made in world maps, and to illustrate a few experimental map types that may prove effective.

TRAVEL-SPEED MAPS

Rates of travel have usually been shown on maps by indicating the limits of travel in all directions from a given center—London, Berlin, or New York, for example—in successive days. Such maps and charts are sometimes called "isochronic." Examples are to be found in Philips' *Centenary*

Mercantile Marine Atlas (1936), plates 4 and 31; in Charles O. Paullin's *Atlas of the Historical Geography of the United States,* edited by J. K. Wright (New York, 1932), plate 138 (New York being shown as a center, as of 1800, 1830, 1857 and 1930); and in Eugene Staley, *World Economy in Transition* (New York, 1939), p. 8 (showing travel time in days from Boston, 1790–1798). An excellent series of somewhat similar maps, called "isohemeric," showing days-travel distances chiefly in Europe, from 350 B.C. to 1888 A.D., is in Wilhelm Götz, *Die Verkehrswege im Dienste des Welthandels* (Stuttgart, 1888).

A chronological series of such maps may give a clear idea of the increases in speed, reckoned from a single city. The acceleration of travel speeds during the last century is sometimes represented by a brief series of maps, the size of the latest maps contracting almost to the vanishing point as the time element in travel is reduced.[1]

Neither method is adequate. We are interested in travel everywhere, in all directions, not only from a single city. The second mapping device simply represents in graphic form a figure of speech. The shrinking of the time factor, however, doesn't make the world smaller in any proper sense. The new inventions may be regarded as having greatly increased human stature and stamina, enabling all of us today to do vastly more in a physical sense than our ancestors ever dreamed of doing. Incidentally they create the need for larger and more detailed maps, not for simplified miniatures.

The map of the United States (Fig. 1) indicates approximately the distances that may be feasibly traveled by surface means in 1940, in all directions and between any points. Graphically the method is analogous to relief maps, in which higher elevations are shown in darker shadings. Here the areas in which travel is slowest are shown in the heaviest shadings, those where travel is fast in light shadings. This type of travel-speed map may appropriately be called an "isotachic map"—borrowing from the Greek a word meaning "equal speed." Along the better highways and roads—the "ribbons of land dedicated to movement"—belts 25 miles wide are shaded on the map, the shading of each belt representing roughly the miles per day that may be traveled by the fastest means of surface travel that may be utilized—whether by automobile or train, or on horseback.

Although roads are seldom as much as 50 feet wide, the belt 25 miles wide seems justified in these days of numerous hard-surfaced roads because, in at least most of the United States, private farm roads and secondary public roads are such that one may go as far as 12½ miles, if necessary, within an hour or two, and reach one of the hard-surfaced roads on which travel at 20 or more miles per hour is readily feasible. There are, however,

[1] Examples are in Staley, *op. cit.,* p. 6, and in Jones, Stephen B., and Klaus Mehnert: "Hawaii and the Pacific," *Geographical Review,* v. 30 (1940), p. 359.

areas in the Far West where, as soon as one gets off the highway, travel is very slow, on horseback or on foot, and in those areas possibly the 25-mile belt should be reduced in width. The classification of automobile highways,

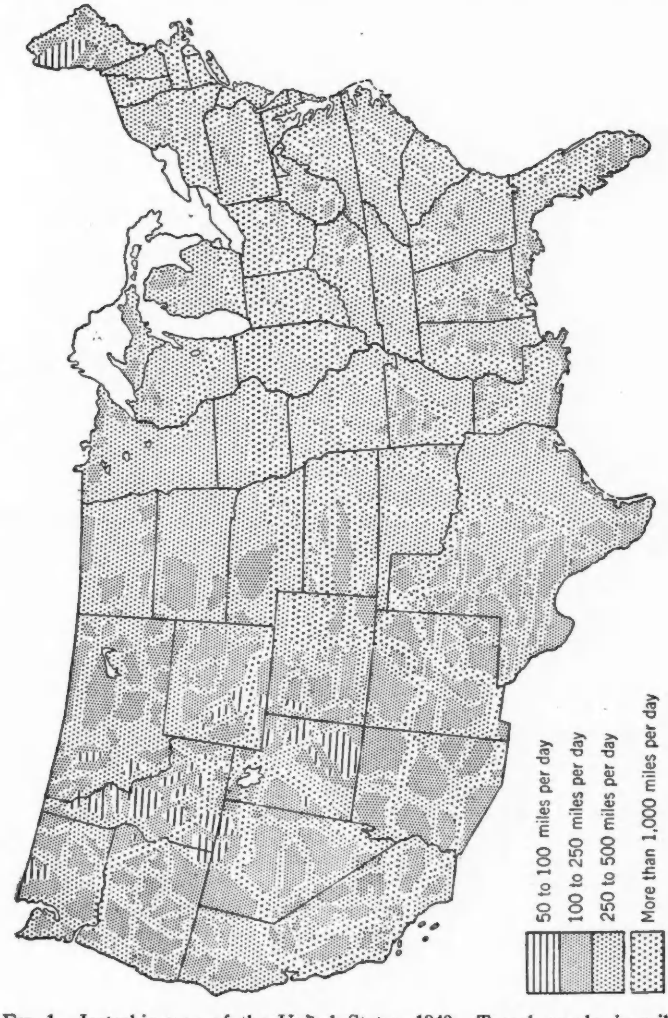

FIG. 1.—Isotachic map of the United States, 1940. Travel speeds, in miles per day, which it is feasible to travel by the fastest available surface means—railroad, automobile, horse-drawn vehicle, etc. Tentative and experimental.

in making this experimental map, is based largely upon data and suggestions furnished by several travel bureaus and by the Public Roads Administration, and upon road maps obtained from them. The author has assumed that the average automobile driver will not exceed 500 miles per day even on the best roads, without undue fatigue, and that on first-class roads the driver may readily make more than 250 miles a day.

The belts or zones with the lightest shading represent the railroads on which it is feasible to travel 1,000 or more miles per day—a distance greater than any day's travel by train in Europe. Speeds even greater than 1,400 miles per day are maintained in this country, and it is possible to cross the continent from coast to coast by railroad in less than 60 hours. Possibly the situation might be represented more accurately if the railroad zone were widened at the points where the fastest trains make regular stops. Within an appreciable radius of such stops a traveler may travel by automobile or by other railroad trains, and may catch a streamliner that will take him nearly a thousand miles in the remaining hours of a 24-hour day. On this experimental map no attempt is made to indicate the railroads on which 500 to 1,000 miles may be covered in twenty-four hours; it would comprise a large part of eastern United States. The difficulties involved in studying passenger time-tables and taking connections into account have precluded the effort.

The isotachic map of the United States in 1800 (Fig. 2) is strikingly different. The greatest speed on the main post roads was between 50 and slightly more than 100 miles per day in the best summer conditions, and sometimes involved all night driving.

The map is based chiefly upon the sources used for the map of "Main Post Roads, 1804," in the Paullin-Wright *Atlas of the Historical Geography of the United States,* plate 138J, as cited on page 134. The diagrammatic time-table entitled "Progress of the mail on the main line," on Abraham Bradley's *Map of the United States Exhibiting the Post Roads* was especially useful, in determining miles per day traveled on the mail route from Brewers, Maine, to St. Mary's, Georgia. The distance of 1,799 miles was made, on the south-bound journey, "summer establishment" schedule, in 46 days, averaging 39.1 miles per day. From Portland, Me., to Savannah, Ga., the rate averaged somewhat more than 50 miles a day. Between Portland, Me., and Richmond, Va., mail was carried three times a week. More than 100 miles a day was made between Hartford, Conn., and Philadelphia, the 234 miles being covered in 50 hours, lapsed time, leaving for example on Monday at 5 A.M., arriving Wednesday at 7 A.M., with travel during both nights. Remarkable speed was maintained over that portion of the route between New York and Philadelphia, the only part where mail was carried daily except Sunday. The 95 miles was made in 18 hours, leaving New

York at 1 P.M. and arriving at 7 A.M. next morning in Philadelphia. In Figure 2 the roads on which travel was slower than 50 miles a day are repre-

FIG. 2.—Isotachic map of the United States, 1800. Travel speeds, in miles per day, which it was feasible to travel by the fastest available means—horse-drawn vehicle, on horseback, by boat or canoe. etc. The map is experimental and subject to much revision.

sented by shaded belts which are 10 miles wide, because secondary roads were so few and so poor; the roads on which more than 50 miles a day was feasible are shown by belts 25 miles wide, as on the 1940 map, but this width may be excessive for conditions in 1800.

This map is subject to much improvement in detail, especially with reference to river travel, and to travel on horseback along Indian trails west of the Alleghanies. But it is an aid to historical perspective. Comparing the 1940 isotachic map of the United States with that of 1800 it is as though giant steam shovels and grading machines had leveled off the mountains and smoothed them like a billiard table.

Similar maps of the entire world, as of different dates, are desirable. These maps of the United States simply suggest graphic means of portraying essential data which might be employed on world maps. A chronological series of isotachic maps of the world would show but a very narrow range of low travel speeds a century ago, whereas today they range from perhaps fifteen miles a day in chairs carried on human shoulders in rugged country, to 3,000 miles or more in a day by airplane. Maps of this type showing air routes and speeds would show the greatest increases in speeds over a short time, and should usually be made to show only the regularly operating commercial air routes.

COMMUNICATION MAPS

A century ago communications were carried only by hand and by the conveyances by which men traveled—except occasionally by carrier pigeon. Large regions were quite unknown to each other. Today communications with the antipodes may be instantaneous, and even with limitations of facilities currently imposed by war, a message might be conveyed within a week or ten days between any two points which are most remote from each other.

Communications maps have been limited chiefly to those showing facilities; telegraph and cable lines, wireless stations, postal routes by railroad and rural delivery, and by air. It would be instructive to devise maps to visualize the cost of communication in all parts of the world at different dates, and to show the vast increase in volume of mail and messages with decreasing costs and expanding services. The initial rate of $5 per half ounce for letters carried by the famous Pony Express between San Francisco and Missouri in 1860–61, is more than five times as great as the air mail rate half-way round the world today. It required from nine to sixteen days to make the trip by pony, and the twenty-pound limit of mail for each pony was seldom reached.

TRANSPORT COSTS

We cannot readily appreciate the effect upon industrial development

and civilization of the great reductions in transport costs per ton-mile which have made it economically feasible to haul millions of tons of grain, ore, and other bulky, low-value raw materials over routes thousands of miles long. It is significant that the range of unit costs is greater than ever before in history. Water-borne freight moves at a small fraction of a cent per ton-mile; railroad freight in different parts of the world[2] at an average of somewhat less than one cent to approximately three cents per ton-mile; by caravan and by human porters the cost varies from perhaps 10c to several dollars per ton-mile.

Transport maps have usually shown established routes, or volume of traffic over the principal routes. Figure 3 represents an attempt to visualize the approximate costs of freight transport per ton-mile prior to the interruption of services by war.

This map is experimental and tentative, and is based chiefly on the map entitled "Means of transport and communications," plate 3–4, in *The Chambers of Commerce Atlas,* London, 1925, and upon data obtained from many sources regarding the cost of transport per ton-mile by prevailing means available in various parts of the world. Transport by dog-team in Alaska, for example, is said to cost from about $2.00 to $15.00 per ton-mile, but is, of course, employed only over snow and ice, in the winter, and only with light loads. It would be desirable to revise the map with reference to the means of transport, and to obtain data from numerous travelers as well as by research regarding present costs of transport. For similar maps of earlier dates extensive research would be required.

On all the areas heavily shaded primitive surface means of transport entail costs that are prohibitive except for goods of great value in proportion to weight and volume. In every such area there is a steady increase in the use of aeroplanes for transport, materially reducing the cost per ton-mile in many instances.

It would be enlightening to devise similar world maps to show the costs of transport of bulky freight and of typical commodities per ton-mile, as of different dates. Although it would be difficult to express unit costs, over a long period of time and in different parts of the world, in comparable terms, the best approximation would be both significant and interesting.

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[2] According to *Foreign Railway News,* published by the Bureau of Foreign and Domestic Commerce, U. S. Department of Commerce, April 15, 1938, railway freight rates in cents per ton-mile, as given in "Canadian Transportation," April 1938, included the following: France 3.48, Great Britain 2.73, Italy 2.71, Europe (average) 2.68, Austria 2.50, Germany 2.48, China 2.19, Mexico 1.77, Argentina 1.74, India 1.08, Canada 0.98, United States 0.94, and Japan 0.77. Similar data for thirteen countries, including several not listed above, may be found in *Quiz on Railroads and Railroading,* published by the Association of American Railroads, July 1940, Question No. 236.

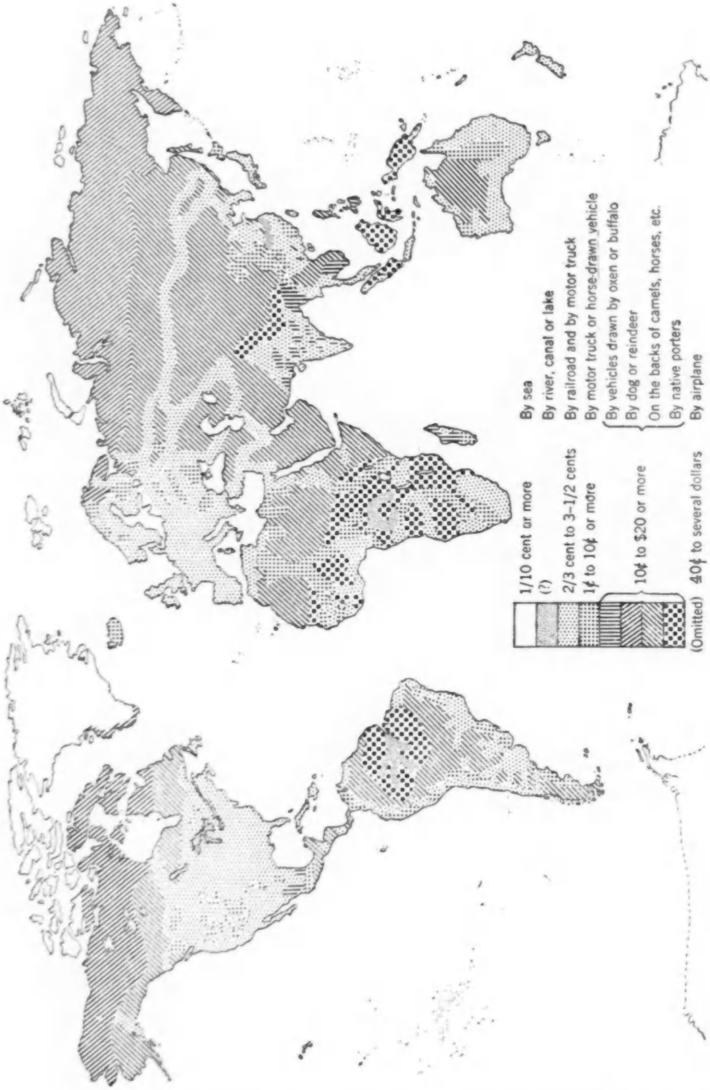


FIG. 3.—The World: Transport-cost per ton-mile, 1940. This map is experimental and subject to thorough revision.

In China, about the beginning of the present century, it was reported that a single man, with a pole and baskets, would carry 80 lbs. about 25 miles a day at a cost of 10c, or at the rate of 11c per ton-mile. (Guy Morrison Walker, *The Measure of Civilization,* New York 1917, p. 56.) Transport costs a century or more ago were much more nearly alike the world over than today, perhaps even more so if expressed in terms of the local average day's wage instead of in a single monetary standard. "Around 1800–1825 long land movements of bulky freight in the United States were said to cost, on the average, about 33½ cents per ton-mile, but were rarely attempted." (Staley, *op. cit.*, p. 17.)

NATIONAL ECONOMIC BARRIERS

Concurrent with these phenomenal developments whereby men, ideas, and goods are conveyed rapidly and inexpensively has come the raising of higher barriers at many international boundaries. The structures of tariffs, import quotas, exchange control, and other devices, have thus far defied efforts to present on maps in quantitative terms the differences between the economic fences erected at international boundaries in recent years. Their excessive heights are anachronistic. Attempts have been made on maps, by drawing pictures of brick-like fences of varying heights, to suggest the height of European tariff walls. Possibly maps may yet be developed to show the relative effect of boundaries of specific countries at different times, but it will admittedly be very difficult.

In Europe the national economic barriers have been, on the whole, higher than in other continents. In Europe, also, the number of miles of international boundary per thousand square miles of area, and the population per mile of boundary, are much greater than in any other part of the world.[3]

OTHER MAP TYPES TO BE DEVISED

The travel-speed, communication-speed, communication-cost, transport-cost and economic-barrier maps suggested above are by no means the only map types that should be devised to visualize geographic factors of a rapidly changing world. Geographers and other specialists who are in a position to compile such maps may well analyze the significant data and originate still other kinds of maps. Such maps, even though experimental, should be scientific and impartial in the highest practicable degree.

Steamships, railroads, automobiles and airplanes, telegraphs, cables and

[3] See *International Boundaries: A Study of Boundary Functions and Problems* (New York, 1939) pp. 12–17, by the author of this paper; regarding the problems involved in illustrating tariff walls, see p. 110, footnote.

radios, and many other devices and techniques that are transforming human environment, wherever they are found, vastly increase the distance at which any corporate body or any nation may operate economically and efficiently. Rivalries are therefore greatly intensified, and may be manifested anywhere on the entire globe. Cooperation or organization even on a continental scale may not eliminate, but may further stimulate, antagonisms that extend to the ends of the earth.

Today large parts of the world are organizing defense against other large parts. Thinking in world terms is partially paralyzed. But ultimately the instrumentalities that are being so effectively used for brutalitarian ends must be adapted to humanitarian objectives and a world economy. If, when the uncertain conflicts now raging have run their course, those who are thinking and planning in the most comprehensive terms are to exercise a corresponding influence, they should have at hand a series of well prepared maps of the changing world.

Washington, D. C.
January, 1941.

Sequence and Equilibrium in Destruction and Conservation of Natural Resources

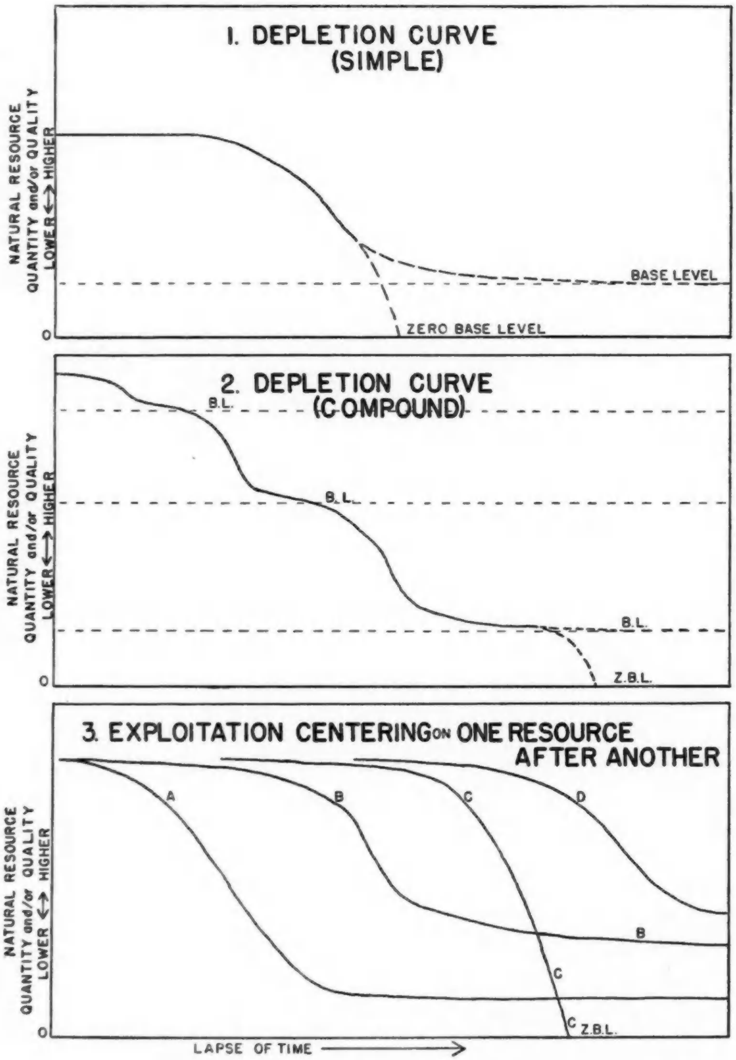
J. R. WHITAKER

One of the major problems of the Twentieth Century is the shrinkage of the natural resource base of communities, regions, and nations. Like many other problems of great social import, that of counteracting resource depletion and deterioration lies within no particular scholarly discipline, but transects many. Traditionally, geographers meet the problem most directly in dealing with the destructive, preservative, and meliorative effects of man on earth resources in specific areas. In the comparative study of those parts of the earth where resource destruction and conservation have been of critical importance, it becomes clear that certain sequences of destruction and renewal are repeated with sufficient frequency to justify their identification as types, and to permit generalizations regarding their occurrence and social significance. Likewise, types of equilibrium, *i.e.,* levels at which resource depletion and renewal are in balance, can also be recognized. In the identification and discussion of these sequences and equilibrium levels, the attention is directed first to those involved in resource destruction.

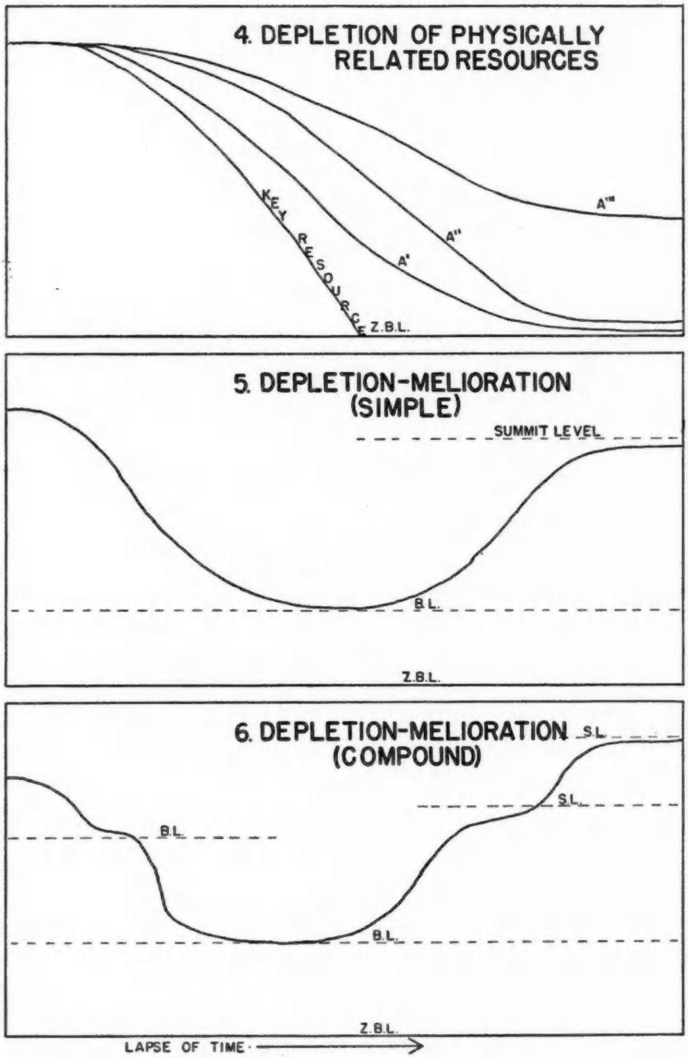
THE SEQUENCE OF DESTRUCTION

Man does not ordinarily live in any area without setting processes in motion which, unless counteracted, bring about deterioration of critical elements in the natural-resource complex. Consideration of the sequences initiated by this damage may well start with the succession found where no effort is made to counteract it, and where depletion exceeds natural renewal. Where not counteracted by nature or man the sequence for a single resource is: **use ⟶ deterioration or depletion ⟶ human want and even distress.** Generally, the growing scarcity of a resource or increasing difficulties in obtaining it slows up the rate of depletion. Ideally, therefore, the curve of depletion begins after a time to flatten out, to reach a base level (Fig. 1, Graph 1). In mining, for example, the resources which can be

FIG. 1.—The depletion and melioration of natural resources. Illustrative of Graph 1 is soil erosion in certain parts of the Appalachians: of 2, iron mining in the Lake Superior region; of 3, the general shrinkage of the natural-resource base of life in the Laurentian Shield in Southern Ontario; of 4, the damage to wildlife, soils, and waters consequent on deforestation of the Driftless Area of western Wisconsin; of 5, the decrease and subsequent increase in the number of seal on the Pribilof Islands; and of 6, soil exhaustion and restoration in northern Germany. (Graphs on pp. 130–131.)



DEPLETION AND MELIORATION OF NATUR



AL RESOURCES (HIGHLY GENERALIZED CURVES)

economically exploited under given techniques and price levels are exhausted, or the accumulation of scrap reduces the demand for new stocks. On the other hand, destruction may drive the resource down to the zero level, to complete exhaustion of the mineral or the extinction of the animal. The sequence is terminated in the second case, even though the resource may have been renewable initially; in the first it is subject to revival and continuance in some form.

Continued decline of the resource reserve, despite warnings present in increasing costs and declining yields, may result from one or more causes.

(1) Habit, custom, or precedent. A fruit farmer in Western Michigan has encouraged soil erosion by planting new trees in such a way that the land has to be cultivated up and down slope because, as he said, the previous land owner had so planted the older trees.

(2) Economic obstacles to reversal of the process. Farmers find that they cannot afford the shift from row to grass crops in order to retard soil erosion. Or, as the land becomes depleted and yields decline, it may be necessary to mine the soil even more vigorously, or to cultivate land which had not previously been so used because of steepness. The poverty-stricken farmer has no alternative. Robert Glendinning has recognized this sequence in a part of the Tennessee Valley;[1] F. C. Erickson, for an area near Chapel Hill, North Carolina.[2]

(3) Lack of technical knowledge. Fred Trenk reports that pastured woodlands may continue to deteriorate despite termination of grazing and efforts to reverse the process. Meredith Burrill notes that in certain erosive areas in the Southwest the soil is gone before farmers have learned how to work their land and still preserve it.[3]

(4) Scarcity value. The lower the resource level, the higher the price of portions of it may become. The price offered by scientific supply houses for rare birds may cause their extermination in particular areas.

(5) The existence of a delicate balance, which, once upset, is restored with great difficulty. Sands set free by overgrazing begin their march.[4] Depleted soils erode because of lower recuperative powers. This is the "out-of-order" concept, to use a phrase suggested by Aldo Leopold. This persistent downward plunge of the resource curve is of tremendous human significance.

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[1] Erosion Conditions in Grainger County, Tennessee, *Econ. Geog.*, Vol. 14, 1938, p. 24.

[2] Land Utilization of the University Lake Drainage Basin, *Econ. Geog.*, Vol. 15, 1939, pp. 301–302.

[3] Geography and the Relief Problem in Texas and Oklahoma, *Southwestern Soc. Sci. Quarterly*, Vol. 17, 1937, p. 295.

[4] Ilia Marshak: *Men and Mountains*, London, 1936, p. 36.

(6) Selfish determination on the part of the exploiters to reap as much profit as possible right now regardless of what may happen in the near or distant future. Very commonly there has been no regard for the welfare of others, no acceptance of the obligation to be good stewards of earth resources.

Resource destruction has been going on throughout human history but, for a variety of reasons, has been intensified during the last century. To note but one aspect: the multiplication of mechanical devices has greatly accelerated the destructive processes, whether fishing or soil mining. This secondary sequence has accordingly appeared: **depletion of the resource ⟶ improvements in and multiplication of machines used ⟶ further depletion ⟶ further mechanization ⟶ fairly sudden exhaustion of supplies available under existing conditions.** Along with the lessened mobility of civilized peoples (not of individuals but of the socio-economic group), this greater capacity for devastation distinguishes civilized from primitive folk. Very commonly the attack of primitive peoples on renewable resources has not exceeded the regenerative rate of nature.

A second, a third, and a fourth period of rapid depletion may be inaugurated by circumstances which favor renewed exploitation of the resource, such as new technologies, a stronger demand for the product, or a sudden rise in price (Fig. 1, Graph 2). Placer gold mining furnishes a good example. The introduction of dredging made it possible to work over gravels previously washed, thus driving down the amount of gold left in the gravels. The rise in price of gold in the 1930's did the same thing. Depletion begins to level off where technology or price no longer are sufficient to overcome increasing difficulties. I have reported elsewhere on the Negaunee iron-mining district of northern Michigan as a sample of this complicated type of exploitation.[5]

Another example is supplied by the Norfolk farming area, Southern Ontario. General farming there depleted the already poor soils, and general land abandonment followed. Later the same area was occupied by tobacco farmers. These tobacco lands are showing signs of being reduced to even lower levels of fertility.[6]

Attention has been directed thus far to the decline in one particular resource, be it iron ore or soil or whatever. Quite commonly, however, the depletion is concentrated on a succession of resources—as one wanes another is attacked (Fig. 1, Graph 3). As the more valuable and abundant species of fish in the Great Lakes were exhausted, the attention was shifted

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[5] Negaunee, Michigan, *Bull. Geog. Soc. Philadelphia,* Vol. 26, 1931, pp. 147–174.

[6] Isaiah Bowman: Geography in the Creative Experiment, *Geog. Rev.,* Vol. 28, 1938, p. 16.

to less desirable ones. A similar shift has occurred in the destructive exploitation of the Upper Lakes Region (in the three Lake States and Ontario): from furs and fish to forests and minerals, and then to recreational resources. There is thus a continued impoverishment of the complex of resources on which human life depends, and, as a common accompaniment, a deterioration in human well being. Marjorie Kinnan Rawlings presents this story in fictional form for an area in Florida,[7] Mary Ellen Chase for the coast of Maine.[8]

Damage to associated elements in the resource complex results, also, where a second resource is depleted in a process which is auxiliary to, or perhaps merely concurrent with, the exploitation of the first. One of the more common examples is the destruction of forest in connection with mining. As T. A. Rickard puts it: The modern mining districts of Colorado and Montana—originally forested—are bare and "most of the old mining regions tell the same tale, from Linares to Leadville, from Potosí to Porcupine."[9] Indeed, in parts of Turkey, mining has ceased because of exhaustion of the local timber. The burning of brush in the hunting of wild animals in Lower California, as noted by Peveril Meigs III,[10] is likewise an illustration. Another is the destruction of soil in the strip mining of coal in central Illinois.

Still another type of depletion of an association of resources is that which results because other physical items depend for their existence on the one which is being deliberately exploited (Fig. 1, Graph 4). Outstanding is the damage done to coexistent resources by extensive depletion of the native vegetation. Water, wild life, and soil resources all suffer. Streams are less useful for nearly all purposes, wild animals no longer find a suitable habitat. Soils may wash away. Probably least likely to tear down the natural resource complex in this indirect way is mining, for minerals are, of all resources, least closely related to the others.

The process of resource depletion if carried far enough, threatens to bring want, even distress. Since prehistoric times, this problem has been solved by migration. Indeed, where the possibility of moving on to fresh areas is found, serious want is avoided. This is, unquestionably, one of the more common sequences. The tropical farmer clears a new piece of land,[11] the Finnish farmer of inland Finland did the same in the 18th Century,[12]

[7] *South Moon Under,* New York, 1933.

[8] *Silas Crockett,* New York, 1935.

[9] *Men and Metals,* New York, 1932, Vol. 2, p. 781.

[10] *The Kiliwa Indians of Lower California,* University of California Press, Berkeley, Cal., 1939, p. 23.

[11] Derwent Whittlesey: Shifting Cultivation, *Econ. Geog.,* Vol. 13, 1937, pp. 39–40.

[12] William R. Mead: Agriculture in Finland, *Econ. Geog.,* Vol. 15, 1939, p. 129.

the cotton planter migrated westward, the Ozark hill farmer moves to valley bottoms, the near exhaustion of lobster fisheries on the coast of Maine in the 80's was followed by a shift to the Canadian coast,[13] the lumber industry migrated across the United States. Obviously, this expedient depends on the existence of additional exploitable areas and a high degree of mobility of the human group. It is, however, tremendously wasteful of human resources.[14]

Here, incidentally, an interesting variant frequently occurs. Repeatedly it is found that some of the people do not move. A remnant may remain behind and that remnant is likely to force the resource base further down. In that event, the stranded community continues to exist by lowering its demands on the environment. The cutover areas of Northern Michigan and the Laurentian Shield of Southern Ontario supply examples.

Still another variant has appeared in the 20th Century. As the want consequent on destruction begins to show itself, it may be offset by aids from more richly favored areas, aids which not only help tide over the inhabitants, but also seek to re-establish the natural-resource base. This is substantially the program now contemplated for the Upper Lakes Cutover region.[15]

DEPLETION-CONSERVATION SEQUENCES

If account is taken of processes counteracting destruction, a distinction must be made between renewable and non-renewable resources. The basic or primary sequence of destruction is the only one possible for the non-renewable or fund resources. For renewable resources, the general resource curve may rise, either because natural renewal is exceeding depletion, or because man himself is deliberately assisting in that renewal.

In analyzing renewal, certain reservations are in order. As Victor Shelford insists, there is seldom complete renewal or restoration, for certain original elements have been destroyed.[16] It should be recalled, moreover, that renewable resources cannot be carried on to the up-turn if they have first reached the zero levels. Soils have been removed completely from the granitic bedrock in portions of northern Michigan, the passenger pigeon of eastern North America has been exterminated. This distinction between reversible and irreversible sequences is fundamental.

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[13] Edward Ackerman: Depletion in New England Fisheries, *Econ. Geog.*, Vol. 14, 1938, p. 234.

[14] Nels Anderson (*Men on the Move*, Chicago, 1940, pp. 135–168) has described most vividly the human losses due to migration resulting from depletion of natural resources in selected parts of the United States.

[15] National Resources Committee: *Regional Planning, Part VIII, Northern Lakes States*, Superintendent of Documents, Washington, D. C., 1939.

[16] *Our Natural Resources and Their Conservation*, New York, 1936, p. 486.

The basic sequence, **depletion ⟶ human need ⟶ conservation ⟶ resources restored to the original or a higher level** (Fig. 1, Graph 5), was considered by the German geographer, Ernst Friedrich, to be the normal sequence for resources which could be maintained or renewed.[17] Particularly was he insistent that this sequence characterizes colonial lands, the revival setting in as European culture becomes more thoroughly introduced in the colonial area. He held that *"Raubwirtschaft"* (destructive land use) leads of *necessity* to improvements. He clearly gave too little weight to the alternative sequence in which want leads to further want, with no hope for an up-turn without help from outside.

Although we cannot agree with Friedrich that this destruction-conservation sequence is characteristic of colonial lands, there is no doubt that it is characteristic of those older agricultural areas which have continued to be occupied for ages, where need reaches the point at which "inputs" for conservation become economically possible (as in northwestern Europe).

Fundamental in considering renewal is the distinction between natural restoration and that aided by man. The sequence, **depletion ⟶ rest and natural recuperation ⟶ depletion,** is found in fallowing land and in the alternation of hunting and breeding seasons in controlled exploitation of wild life. Depletion followed by deliberatively restorative measures, as in soil fertilization, may bring a quicker and more complete restoration.

As in depletion, restoration may be a halting affair (Fig. 1, Graph 6). The soil exhaustion of northwest Europe was first reversed by the introduction of root and hay crops, and the productivity of the soil was then raised to higher levels by the use of chemical fertilizers. Regarding the conditions prior to the introduction of root and hay crops, Vladimir Simkhovich wrote, "The state in which the land was found was by and large the upper limit of its productive capacity. It might deteriorate, but it was not likely to be improved."[18] And Siegfried von Ciriacy-Wantrup says that chemical fertilizer has now become the critical factor in soil conservation in Europe.[19]

This general depletion-conservation sequence differs in detail with different resources and under different cultural conditions. Three of these sequences are noted here:

1. **Monoculture ⟶ soil deterioration ⟶ polyculture.** Monoculture, a very common practice in agriculture and forestry, has proved the world over to bring deterioration of the soil. As the process continues, the

[17] Wesen und geographische Verbreitung der "Raubwirtschaft," *Petermanns Mitteilungen,* Vol. 50, 1904, p. 73.

[18] Hay and History, *Pol. Sci. Quarterly,* Vol. 28, 1913, p. 396.

[19] Soil Conservation in European Farm Management, *Jour. of Farm Econ.,* Vol. 20, 1938, p. 98.

soil resource may be driven to the zero level, but it can be arrested in its decline or improved by a shift to polyculture. The German experience with pure stands of pine is illustrative, as is wheat farming in the Willamette Valley. For a splendid study of this type of sequence see the report by A. O. Craven on soil exhaustion in Maryland and Virginia.[20]

2. For biotic resources, a common sequence is: **destruction ⟶ scarcity ⟶ restrictions on take ⟶ restocking ⟶ management of the habitat.**[21] Management approaches but does not make the change from dependence on wild forms to dependence on domesticated forms.

3. **Reclamation ⟶ deterioration of reclaimed resources through use or failure to maintain the improvements ⟶ period of want ⟶ rise of responsible, able authority ⟶ reclamation ⟶ deterioration.** "Reclamation" as a process is something of an anomaly in resource relations. As the word is employed here it is limited to the bringing into use of resources which have little or no value to man without some treatment. Drainage of swamps, fertilization of sandy lands, and irrigation of dry lands are examples. The sequence starts with an up swing. **Human need and the rise of responsible authority ⟶ reclamation of lands ⟶ deterioration through use or failure to maintain ⟶ reclamation by responsible authority.** Here the natural direction of change is toward making the resource *less* useful. Therefore, if human vigilance declines, the resource deteriorates. George P. Marsh, in 1864, viewed this as a characteristic sequence in Italy, and the intervening years have supported his conclusion.[22] S. G. E. Lythe, in writing of drainage in the River Hull Valley, England, says, "The history of fen and marshlands is necessarily episodic. After decades or centuries of inaction, punctuated only by abnormal floods, a Duke of Bedford or a Vermuyden appears, and in a few years reeds and sedge give place to grain crops, malaria disappears, duck decoys are demolished, and the country side takes on a new complexion."[23]

Whereas the depletion sequence taken alone leads down haltingly or steadily as the case may be, the depletion-restoration sequence is very commonly cyclic or recurrent. Once the resource has been somewhat restored, depletion may again occur. Although the same sequence may be repeated, it should be noted that the resource crests (summit levels) may gradually rise or fall. Attention is here directed to the time intervals involved.

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[20] Soil Exhaustion as a Factor in the Agricultural History of Virginia and Maryland, *University of Illinois Studies in Social Science,* Vol. 13, 1925, pp. 1–179.

[21] Aldo Leopold: *The University and Conservation of Wisconsin Wildlife,* University of Wisconsin Bulletin, Madison, Wis., 1937, p. 21.

[22] *Man and Nature,* New York, 1865, pp. 417 ff.

[23] Drainage and Reclamation in Holderness and the River Hull Valley, 1760–1880, *Geography,* Vol. 23, 1938, p. 237.

Cycles of a year's duration are common. In these we include the yearly cycle of soil depletion and renewal where a high, stable level of productivity has been attained. The one-year cycle is also found where the soil has been reduced to a base level at which the food released each year is used up in the crops of that year.

Although these short-time cycles are characteristic of the equilibrium struck in highly conservative farming and also in subsistence farming with no human improvement of the soil, long-time cycles are also involved in soil conservation. In fallowing, the period may last from one to even 50 years, the latter in the shifting cultivation of the humid tropics. O. T. Faulkner and J. R. Markee give four or five years for the period in the more densely settled parts of Nigeria.[24] They also present evidence to show that the later crests of fertility fall short of the original, and are far below that which could be secured if fertilizers were used. As the pressure of population increases, the principal conservation problem of such an area is to displace this long-time cycle of restoration with an equally conservational short-time cycle, thus permitting more frequent periods of depletion through cropping. Where the soil destruction reaches a zero level, if the parent material is bedrock, the cycle involves thousands of years; of loess or glacial clays, considerably less time. The difference in time required for soil to be restored is impressed on one by traveling from hilly areas of residual soil on solid bedrock, where the bedrock outcrops frequently, to areas of deep deposits of till or loess.

The cycles of depletion and renewal of biotic resources vary from a few weeks to several years. Where rains are frequent and depletion slight, the wild grasses of ranges may be restored quickly; elsewhere it may take months or even years. It is significant that rotational pasturage, in which the grass is rested, is being attempted. Fish and other wild life resources commonly involve cycles of but a few years duration; forests much longer periods.

One outstanding trait appears in nearly all cycles. The rate of depletion, the speed of destruction, generally exceeds the rate of renewal. The curve of resource depletion is steeper than that of restoration: the jungle garden is used for perhaps a fourth as long a time as is required for fallowing; and forests may be cut in a few weeks that required centuries to grow. Waiting is thus an essential in the maintenance of cycles of restoration.

Significant, too, is the position of the cycle with respect to the absolute zero level. If high, the possible *take* in each period is high. If the breeding stock of deer is high, the offspring are numerous. But if the stock is badly depleted, the yearly increment is low. From the point of view of

[24] *West African Agriculture*, Cambridge, 1933, p. 36.

human welfare, where cyclic sequences are involved, the low levels are clearly to be avoided.

EQUILIBRIUM LEVELS

This analysis of sequences reveals the existence of resource levels at which the processes of destruction are in approximate balance with the processes of restoration. In a given sequence, however, various types of equilibrium levels may occur.

Before man comes into an area most if not all resources are in a state of equilibrium. The fund resources are definitely so. The biotic resources are in balance with environing conditions, though the equilibrium level is not a static thing, but rises and falls. But as Lewis Mumford has put it, in *The Culture of Cities,* the introduction of any new creature upsets this balance, and "one creature man cannot help introducing—himself."[25] Man is continually upsetting the balances. Mumford suggests that "perhaps the chief problem of human settlement has been to adapt the planet to man's many new needs without completely disrupting the balance of nature."[26]

As in the investigation of other phenomena of equilibrium, it is possible to recognize situations where the balance or equilibrium is *stable, unstable,* or *neutral* (using these terms in the commonly accepted sense). Where a condition of *stable* equilibrium exists, there is a movement back to the original level when pressure is released. This holds for waters in general, and for biotic resources if they are not too greatly modified. With slight human alteration, natural processes can and do restore the damage.

Unstable equilibrium exists where, if upset, the changes continue for a time, coming to a new balance at a very different level; and, as I now see it, this new balance is most commonly at a lower level. Examples of unstable equilibrium are: soils on steep slopes, high forests in the Mediterranean area, soils in karst areas, fixed sand dunes, and most humid grasslands.

Neutral equilibrium exists if the resource remains in the condition to which alteration brings it, with no tendency to move either toward restoration or toward a still lower level. This is characteristic of all mineral resources. It does not appear to exist in soils, waters, or biotic resources.

Even more significant in resource destruction and renewal are *base* and *summit* levels. A *base* level is a level at which the resource tends to become stabilized following a period of depletion (indicated as *base level* or B.L. in Fig. 1). The ultimate base level, the lowest possible one to which the resource can be carried, is reached for soils when they suffer complete exhaustion. For most minerals it is reached with the exhaustion of all materials which conceivably could be recovered. Except where complete extermina-

[25] *The Culture of Cities,* New York, 1938, p. 313.

[26] *Ibid.,* p. 313.

tion or exhaustion has resulted, it is difficult to be sure that a resource has arrived at the ultimate base level. More commonly, other base levels, which we may call temporary, are reached. The base level is highly significant: for fund resources, the higher the level, the larger the remaining resources; for renewable resources, the higher the level, the larger the possible take or harvest or yearly withdrawal without destroying the equilibrium—the greater the number of young salmon for the next run or the greater the harvest from the soil.

What conditions set or bring about base levels? Some of the more common ones are listed here.

(1) Complete exhaustion clearly does.

(2) The pressure of increasing costs tends to level out depletion. As iron ore is mined out under a given market situation, technology, etc., mining slows up and finally stops. With growing scarcity, primitive people move away, thus terminating depletion.

(3) Rate of depletion-and-renewal of a resource under particular condition. This is clearly illustrated by that reached in the nitrogen content of soils under constant cultivation. The loss is most rapid during the first 20 years, when it is about 25% of the original quantity under natural conditions; a 10% loss occurs during the next 20 years; and a 7% loss during the third 20.[27] The end is a new equilibrium at a much lower level than the original. The same type of base level appears where there is continuous cropping of a non-eroding plot with the same crop year after year, with no replacement of plant nutrients. Ultimately a point is reached where the nutrients made available each year are pretty largely used up by the crops of that year. There is evidence that in at least some areas of fallowing (whether it be that of grain-growing in the Palouse or shifting cultivation in the Amazon Basin), soil productivity is lowered to a base level far below that at which it could be held. The same clearly holds for native vegetation, whether it be the forests of the upper Peninsula of Michigan or the woodland of Bengal.[28]

On the other hand, soil depletion by water erosion has no such temporary base level if the land has an appreciable slope; and even on flat land wind can remove all of the soil. Enough has not been made of the relation between the high productivity of alluvial plains and the comparative freedom from erosion by water or wind. In China, the

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[27] Oswald Schreiner and B. E. Brown: Soil Nitrogen, *Soils and Men*, Yearbook, U. S. D. A., 1938, p. 369.

[28] Arthur Geddes: India: (1) The Chota Nagpur Plateau and the Bordering Plains, *Proc. Internatl. Geog. Congress*, 1938, Vol. 2, Sec. iiic, p. 368.

"farmers of forty centuries" have occupied the alluvial plains rather than the hills.

(4) Accumulation of a revolving fund. As metal scrap accumulates the demand for ore declines and mining begins to approach a level at which the need is met by the stocks on hand. Clearly, this level is one that is approached but never reached, unless there should be a notable drop in the requirements for that particular resource. In this aspect of metal utilization is one of the more conservational phases of the stage of technology which the Western World is now entering.

(5) Protection by individual or social groups. Scarcity or the growth of appreciation may make protection imperative. This protection, as in fisheries, may be partial, aiming to preserve a certain minimum reserve; or it may be absolute. Mineral resources may be set aside as reserves against a future need. Large wilderness areas may be dedicated to the preservation of biotic associations. The level is a measure not only of need but of social appreciation and responsibility in meeting that need.

(6). Lessening of demand. The discovery of substitutes may enable the attack to let up sufficiently to establish an equilibrium level. Edward Ackerman notes that the discovery of vegetable oil substitutes saved the whale from complete extinction at the hands of the Nineteenth Century New Englanders.[29] Checks on population growth would do the same. Conservationists have been strangely silent on this solution to the problem, yet even primitive peoples have known and practiced control of population growth in order to bring demand and resources into equilibrium.

A *summit* level is a level which a resource approaches or reaches as a result of a period of restoration (indicated as *summit level* or S.L. in Fig. 1). In renewal of forests the maturing trees approach a certain density, one level being reached for Douglas fir, another for birch. Students of game birds have shown that a density is reached beyond which numbers do not multiply. In the study of the virgin organic content of soils, it has been demonstrated that there is a summit level in the organic content, a level which decreases as the average annual temperature increases. This is considered to be a consequence of the rapid increase in decay as the temperature rises. William Albrecht has reported that in southern Minnesota, for example, virgin soils are in a condition of natural equilibrium at an organic-matter content of 4.44%; in northern Missouri, 3.54%; in Arkansas, 1.96%. Albrecht concludes "It would be folly, according to these data, for the farmer in Arkansas to attempt to increase organic matter

[29] Ackerman: *op. cit.*, p. 235.

in his soil to the level common in the soil tilled by the Minnesota farmer."[30] To do so would be to work against forces which tend toward stabilization of the organic matter at a level much below that normal to Minnesota.

In connection with possible summit levels, the extent of depletion of a resource and its critical associates prior to restoration is of major significance. For biotic resources, the height to which the resource can be carried depends in part on the reproducing stock, in part on the carrying power of the range. The possible summit level may be permanently lowered by injury to the renewable resource. In the Mediterranean, for example, fire, pasturing, and charcoal burning have stabilized as garrigue or maquis many areas formerly in high forest. On the other hand, there is generally an absolute summit level above which, even under ideal conditions, the resource will not rise, whether it be timber, quail, or the organic content of the soil.

A warning here is justified. Efforts by governments through subsidies to push the summit levels beyond points of normal equilibrium simply create a situation in which collapse is imminent—as in expensive irrigation or drainage or elaborate works for the control of soil erosion.

ESCAPES FROM DESTRUCTIVE ECONOMY

The consequences of a destructive economy may be avoided, as I have been pointing out, by preservative and meliorative activities; in other words, by conservation. Still another partial solution, and one too commonly overlooked by conservationists, is present in a sequence which is of even more common occurrence, so far as biotic resources are concerned, than the destruction-conservation succession. The sequence is: **destructive occupation ⟶ human need ⟶ productive occupation**; or, as more commonly stated, destructive exploitation leads to production of domestic plants and animals. Perhaps, when all is known, the domestication of plants and animals will prove to have been the principal way in which man has met the problem of resource depletion. This substitution has greatly compensated for the tremendous reduction in recent centuries in the earth's population of wildlife.

The student of wildlife may insist, and rightly so, that much has been lost by this substitution, particularly in aesthetic values; that the future range of evolution of both wild and domestic forms has been greatly curtailed; and that much land and water not suited to production of domestic plants and animals has been depopulated of its wild forms. On the other hand, the basic needs of food and clothing of humanity have been met as the wild forms have been forced to give ground to those which man has tamed to his own use.

[30] Loss of Soil Organic Matter and Its Restoration, *Soils and Men*, 1938, p. 354.

At first thought, one might assume that it is only the destructive use of wild biotic resources that leads to productive occupance. Actually, the exploitation of minerals has repeatedly had a similar consequence. Around the mining towns of Laurentia are agricultural communities, and I have shown in an earlier paper that mining has been in large part responsible for the agricultural occupation of the Upper Peninsula of Michigan.[31]

We should not fail to note, however, that productive utilization of the land, while it may follow destructive exploitation and substitute for it in meeting men's needs, may in itself be destructive. Cereals may be grown in place of wild rice, but if in a system of monoculture, the substitution shifts the destruction from wild plants to the soil. Truly, therefore, the problem of conservation is not met by a change from resource destruction to productive land use unless that use is in itself designed to conserve the critical elements in the resource complex. Land use that is both productive and conservational is found in northwestern Europe, where the agriculture is based on forage crops, livestock, and artificial fertilizers, with a proper combination of soil-building and soil-depleting crops.

In this shift from dependence on wild forms to domesticated forms goes, too, a certain disregard for natural balances. The student of human behavior may insist that most of man's needs are being met by domestic production, but the ecologist may point to disrupted biotic associations and assert that in the end man will lose. Certainly this is clear, that we do not now know the full extent of the losses that come from our deliberate disregard for the preservation of ecological balances.

Besides ignoring the sequence in which destructive exploitation gives way to production of domestic plants and animals, students of conservation of natural resources also frequently lose sight of the likelihood that destructive land use may lead to what Jean Brunhes has called unproductive or sterile land use.[32] Brunhes' choice of a term to describe this class of facts may seem unwise to us, but the distinction is fundamental. Such activities as lumbering, fishing, and soil mining promote the construction of roads, dwellings, and factories, features which quite commonly continue to serve man long after the destructive processes cease, attract men who turn later to manufacturing or commerce, and provide capital with which to finance those undertakings. New England industry was in part reared on the

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[31] Relation of Agriculture to Mining in the Upper Peninsula of Michigan, *Jour. of Geog.*, Vol. 25, 1926, pp. 21–30.

[32] *Human Geography*, New York, 1920, pp. 48–49. Also see scattered notes in Jean Brunhes and Camille Vallaux: *La Géographie de l'Histoire,* Paris, 1921. Other references of a more general nature than most of those cited above are listed in *Ann. Assn. Amer. Geog.*, Vol. 30, 1940, pp. 143–162.

earnings from fishing; the petroleum wells in the South are supplying capital for new industries there; and, as George Jenkins has pointed out, the features produced by exploitation, such as abandoned mines, have historical and scenic value, and may form the basis of a new economic activity —the tourist business.

These "unproductive" land uses, may, however, damage the natural environment and they generally depend in large part on natural resources drawn from other areas. The source of supply of natural resources rather than the user migrates where unproductive land use takes the place of destructive exploitation.

Four primary sequences involving the destruction of natural resources are thus recognizable:

1. **Destructive use ⟶ exhaustion of resources and consequent want, migration, or extinction of human society;**
2. **Destructive use ⟶ restoration of resources by natural and/or man-induced processes;**
3. **Destructive use ⟶ productive land use (sustained production of domestic plants and animals);**
4. **Destructive use ⟶ unproductive use (uses no longer dependent on the consumption of local natural resources).**

The possibility of displacing the first sequence by one or more of the remaining three stands as a challenge to any forward looking community, region, or nation.

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October, 1940.